AD-A075 801 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL F/G 5/3
IRELAND/UNITED KINGDOM-RESEARCH CONSORTIUM. REPORT NUMBER 1. TH--ETC(U)
FEB 79 T F BOLAND

UNCLASSIFIED NL

| OF |
AD
A075801

END
DATE
FILMED
11-79
DDC

IRELAND/UNITED KINGDOM - RESEARCH CONSORTIUM

REPORT No. 1

LEVEL II

The Construction Industry - A Perspective

by

Thomas F. Boland

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) IRELAND/UNITED KINGDOM-RESEARCH CONSORTIUM. REPORT [redacted] Number 1. THE CONSTRUCTION INDUSTRY-A PERSPECTIVE,		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS (10) Thomas F./ Boland		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005, Champaign, IL 61820		12. REPORT DATE (11) 9 February 1979 13. NUMBER OF PAGES 71
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 78		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service
Springfield, VA 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

construction industry
resource requirements

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report identifies the construction industry as an entity in the sociocultural realm and develops a perspective of it by:
-- describing it in general;
-- developing of it a notational physical structure and form;
-- identifying the purpose for which it and its component entities exist;
-- describing parameters that may be used to assess the degree to which it and its entities fulfill their purpose; (over)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 405 279

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20 continued.

-- identifying it and its component resource requirements and the outputs expected of them, and
-- examining its ability to monitor and adapt in response to internal and external influences.

FOREWORD

W-65, Organization and Management of Construction, is a Working Commission of the International Council for Building Research Studies and Documentation (CIB). The Terms of Reference for this Commission is: "To develop effectiveness calculations and techniques for evaluating singularly and collectively various organizational forms utilized in the planning, architecture, engineering, construction, and ownership stages for both conventional construction and for industrialized construction. The aim will be to provide tools which will enable comparisons to be made between alternative organizational structures and management doctrines in the enterprises responsible for each facet of the building process."

One of the programs of the Commission is that of cooperative research on an international scale. This report is a result of a consortium of researchers from Ireland, England, and Canada. Mr. T. Boland of the National Institute for Physical Planning and Construction Research in Dublin, Ireland served as the principal investigator.

Additional copies of this publication can be obtained from the National Technical Information Service, P. O. Box 1553, Springfield, VA 22151. Information on CIB can be obtained by contacting Mr. J. R. Janssens, Secretary General CIB, Postbuss 20704, Weena 704, Rotterdam, Holland. Information on the Other programs of W-65 can be obtained from either Mr. Janssens or myself.

US Army Corps of Engineers
Construction Engineering Research Lab
P. O. Box 4005
Champaign, IL 61820

L. R. SHAFFER
Coordinator, W-65

9 February 1979

ACKNOWLEDGMENTS

The author acknowledges with gratitude the assistance given by all the members and guest members of the Ireland-United Kingdom Research Consortium for their work in contributing to the report, to the questionnaires and in the analysis of the questionnaire responses. Thanks are also due to the members of Working Commission 65 of the International Council of Building Research and Documentation (CIB W-65), who gave of their time to offer comment and respond to the questionnaire.

Particular reference must be made to the generous and in-depth contributions of Professor Roy Pilcher, Mr Peter Cheesman and Mr William McEvatt.

The author also acknowledges with gratitude the assistance and encouragement of Dr. L.R. Shaffer, Coordinator of CIB W-65 and of Dr G.N. MacKechnie, Trinity College, University of Dublin.

IRELAND/UNITED KINGDOM RESEARCH CONSORTIUM

Mr Thomas F. Boland	An Foras Forbartha, Dublin, Ireland
Mr Peter Cheesman	Heriot-Watt University, Edinburgh, U.K.
Professor Vir Handa	University of Waterloo, Canada
Professor Roy Pilcher	The University of Manchester Institute of Science and Technology, Manchester, U.K.

GUEST MEMBERS OF THE RESEARCH CONSORTIUM

Mr William McEvatt	An Foras Forbartha, Dublin, Ireland
Dr. Patrick Perry	Imperial College of Technology, London, U.K.
Mr Tony Sidwell	The University of Aston, Birmingham, U.K.
Professor Helen Tippet	Victoria University of Wellington, New Zealand
Professor Victor Torrance	Heriot-Watt University, Edinburgh, U.K.

OTHER CONTRIBUTING MEMBERS OF CIB W-65

Mr L.J. Brown	National Defence Headquarters, Ottawa, Canada
Dr. W.J. Diepeveen	Stichting Bouwresearch, Rotterdam, The Netherlands
Dr M.T. Pavlidou	Thessaloniki, Greece
Professor S. Peer	Technion - Israel Institute of Technology, Haifa, Israel
Dr L.R. Shaffer	Construction Engineering Research Laboratory, Champaign, U.S.A.
Mr H. van den Born	Bouwcentrum, Rotterdam, The Netherlands
Mr B. Whitehead	University of Liverpool, Liverpool, U.K.

CONTENTS

INTRODUCTION

The report that follows is the first from the "Ireland/United Kingdom Research Consortium". This consortium was initially set up at the third CIB W-65 meeting held in the National Acadamy of Science, Washington D.C. on 1976 May 21. At the first meeting of this research consortium held in the Heriot-Watt University, Edinburgh on 1977 September 13, it was agreed that its terms of reference be based on developing the ideas expressed by the author in his paper titled "Morphology of the Construction Industry" which was presented to the seventh CIB Congress. This meeting also decided that the author would act as lead member.

The terms of reference subsequently agreed by the group at its second meeting held in UMIST, The University of Manchester, Institute of Science and Technology on 1977 December 21, read as follows:

"To develop a Morphology of the Construction Industry to the extent of testing a profile of the construction industry.

The aim will be to:

"Identify functional and performance requirements, firstly of the construction industry as an entity and secondly of its individual elements, processes and conceptual linkages.

Use the morphological representation as a common denominator for international comparison of the construction industry.

Identify and, where necessary, quantify the resources and activities both endogenous and exogenous of the morphological representation.

"The developed morphology of the industry will be oriented towards use by research policy formulators, educationalists, designers and constructors. It will fulfil a normative and predictive function. It will enable the response of the construction industry to current and predictive demand to be assessed. It will enable the efficiency and the effectiveness of individual entities to be assessed. It will lend itself to the testing of organisations for projects. It will enable the influence of external factors on the industry to be assessed as well as facilitating the identification of retardants to rationalisation".

The approach adopted in this report was to view the sociocultural realm as an ensemble of interrelated entities. Figure 1 is an attempt at depicting diagrammatically a notional organizational perspective of the sociocultural realm. Here it will be observed that the entities are portrayed as being related to each other by a causal network. The network consists of nexus that may be conceived of as being essentially psychic communicative channels involving complex information exchange processes. The information transmitted via the network of most concern in this report can be categorized as being:

- social
- economic
- technical

The construction industry is an entity in the ensemble of sociocultural systems and it is itself composed of an ensemble of interrelated entities. This report confines itself to identifying the construction industry as an entity in the sociocultural realm and thence developing a perspective of it by:-

- describing it in general,
- developing of it a notional physical structure and form,
- identifying the purpose for which it and its components entities exist,
- describing parameters that may be used to assess the degree to which it and its component entities fulfil their purpose,
- identifying it and its component entities resource requirements and the outputs expected of them,

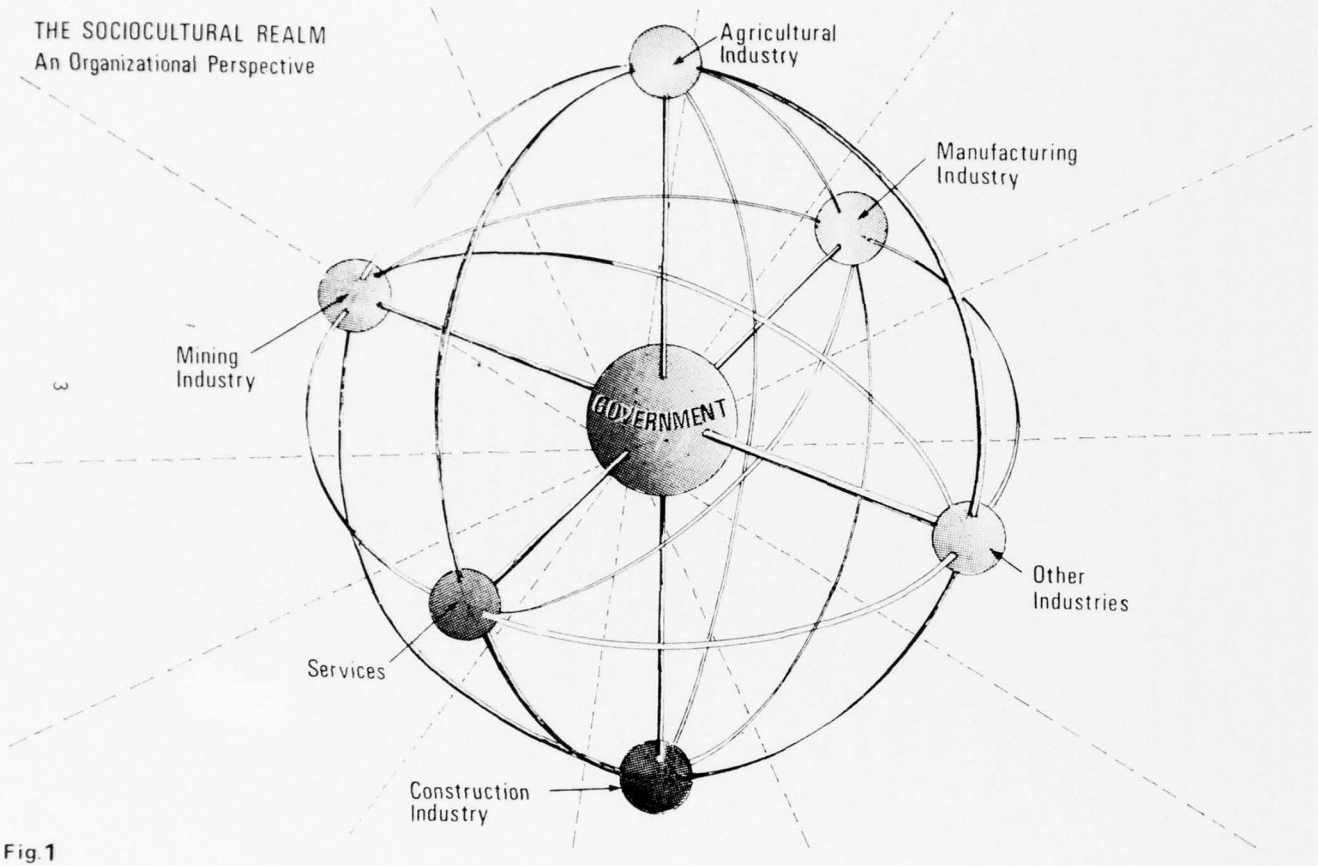
THE SOCIOCULTURAL REALM
An Organizational Perspective
Agricultural Industry
Manufacturing Industry
Mining Industry
GOVERNMENT
Other Industries
Services
Construction Industry

Fig.1

- examining its ability to monitor and adapt in response to internal and external influences.

The method of working adopted by the research consortium was that the lead member prepared a discussion paper, a draft term of reference, a draft timetable and a draft questionnaire. A meeting was then convened in UMIST, the University of Manchester, Institute of Science and Technology, Manchester, U.K. on 1977 December 21 at which members and guest members discussed in a searching and positive manner all of the documents. Decisions were minuted and all members committed themselves to responding to the questionnaire as revised by the meeting.

Following the analysis of the questionnaire by the lead member, a meeting was convened in An Foras Forbartha, The National Institute for Physical Planning and Construction Research, Dublin, Ireland on 1978 April 19 for the purpose of establishing a consensus response to the questionnaire. The questionnaire accompanied by the Consensus response was then dispatched to all CIB W-65 members for the purpose of obtaining an international response to the questions posed in the questionnaire.

A draft report incorporating the synthesised response to the questionnaire by the CIB W-65 members was presented to the fifth CIB W-65 meeting held in Technion, Israel Institute of Technology, Haifa, Israel on 1978 November 3. The author undertook in accordance with the wishes of this meeting to prepare a final draft and forward it to Dr. L.R. Shaffer, Coordinator, CIB W-65 for distribution to the Commission and for publication in NTIS, the National Technical Information Service, Department of Commerce, United States of America.

The views and opinions expressed in the report are those of the author who was influenced in his writing by the views and opinions of those referred to in the acknowledgement and by the works of those mentioned in the footnotes.

CHAPTER I

THE CONSTRUCTION INDUSTRY – THE NEED FOR A PERSPECTIVE

Most construction industry research is predicated on the assumption that its research community, its clients and its constructed facility designers and construction organizers know what the construction industry is. It can even be argued that whatever successes have been achieved by the construction industry have been derived from the willingness of these people to defend this assumption.

However, if the construction industry is, or exists, then it is, or yields, a classification. Whatever is assigned a place in this classification is given some ontological status, and to have some ontological status is to be an entity. Just as the construction industry exists as a classification of entities, it is itself an entity in a larger classification, a classification called the "sociocultural realm".

Despite our acknowledgment of the existence of the construction industry, we are at pains to articulate its description. A dictionary won't help very much in this regard. It will define separately the words "construction" and "industry" but will not define the entity "construction industry".

In point of fact not only do we not have a generally accepted description of the construction industry, but also we do not have of it a theoretical model or perspective. Yet a wealth of research has been, and is being, conducted concerning the construction industry, and in the absence of both an explicit description and

theoretical perspective, this research can at best be categorized as "piecemeal".

It would be paralogical to suggest that we can conduct research into, and develop logically systematic, deductive theories of, and concerning, the construction industry in the absence of some explicit or implicit perspective, philosphy or model informing our thinking. Yet the perspective of the construction industry informing our thinking is ordinarily not only implicit but if asked to describe it, we are at pains to articulate an answer. This being the case there is a need to call on research for assistance. Research, however, operates, from an analytical point of view, at three distinguishable levels:

- Perspective, conceptual, model or philosophy development research,
- Logical systematic deductive theory research,
- Empirical research .

Regretfully research at the first level is largely neglected in the construction industry, and yet it is the necessary ingredient to inform our approach at the latter two levels.

As the construction industry as a system is open internally, as well as externally, the lack of perspectives is everywhere manifest. It is manifest at the level of:

- Construction industry consideration, where a sociocultural realm perspective is needed to inform,
- Construction industry component entity consideration, where a construction industry perspective, compatible with

the sociocultural realm perspective is warranted,

- Construction industry component entity activity consideration, where perspectives of the component entities, compatible with the construction industry perspective are needed to inform,
- At successive subordinated levels, where the perspective used to inform, needs to be compatible with the perspectives at the superior levels.

Reference to literature provides ample evidence of the real need for perspectives and also of the desire that effort be devoted to satisfy this need. Consider for example the following extracts from the repertoire, on a sectoral basis, of proceedings from the various symposia, congresses, seminars and colloquia held at various national and international levels:

"... This re-definition of building research is characterized by two different attitudes: social responsibility on the one hand, pragmatism on the other. I am suggesting that we make no compromise in defining the goals: we should develop a normative model of the building industry of tomorrow that best matches the needs of society...."

"We should be less afraid to dream, to develop socially desirable goals for improving the quality of our built environment".

A.D. Bernhart, U.S.A.
6th CIB Congress
Budapest, 1974

"... traditional technological research methods are of little use when studying problems of the total environment. What use is the favoured research method of cutting free one little detail to be able to study it in peaceful isolation, when the human environment is characterized exactly by its complex interdependency of large numbers of factors?"

P.H. Arctander, SBI, Denmark
6th CIB Congress
Budapest, 1974

"Improved planning and scientific and technical progress needs to be based on integrated measures covering the entire 'science-technology-production' complex".

Long-Term Prospects and
Policies in the Construction Sector
United Nations, New York, 1976

Accepting that the proceedings from such gatherings are the repository of the "vertstehen" of participants, one will observe on reading then, as evidenced by the above abstracts, that there is a consensus vertstehen regarding the role of research at the level of perspective development. Bernhart expressly advocates the need to develop a perspective of the construction industry, whereas Arctander identifies the need by pointing to the injudiciousness of studying details of an ensemble in isolation from its perspective. The United Nations voices its concern at the lack of a perspective or as it says a means of integrating the entire "science-technology-production complex". The concern of the United Nations might be better understood by reflecting on the way in which research operates.

TABLE I

RESEARCH				
		STAGES		
	LEVELS	1	2	3
1	Philosophical	Hypotheses - proposal	Hypotheses - testing	Deduction
2	Theoretical	Theory Development	Technology Development	Testing
3	Empirical	Data Collection	Analysis	Deduction

It has been stated above that research, analytically speaking, operates at three distinguishable levels. Within each level, research takes place in a number of stages. Table 1 outlines such a breakdown. When considering theoretical research on the construction industry for example it will be observed from Table 1 that it takes place in three stages and in practice each stage ordinarily takes place independently of its

preceding stage, and, arguably, informed by different implicit, perhaps even subconscious concepts of the construction industry. There is thus a lack of integration between the individual stages of this level, which was referred to by the United Nations and which may be described as:

- The scientific stage where academic and other intersectoral institutes produce fundamental research,
- The technological stage where either these same, or more usually, sectoral research institutes concern themselves with the application of these fundamental research results and make their findings known in the form of scientific and technical reports or other documents,
- The testing stage where the stage two results are taken by the laboratories of the above or other sectoral research institutes and tested.

On the culmination of the final stage the findings are usually passed on to the industry. Very often the last stage is conducted by way of a pilot study in the industry by the stage two personnel and with less favourable results.

This is so as the enterprise conducting the pilot study has ordinarily to:

- simultaneously contend with two systems; the existing and that which is under test,
- adapt the innovation to prevailing circumstances or vice versa.

This division of interest and the lack of ideal test conditions is apt to result in a dilution of the performance inherent in the novelty. Arguing, therefore, that there is a lack of integration in the three stages of level two is merely stating the prevailing condition. The absence of a perspective, however, is almost an absolute guarantee against effective integration ever being achieved.

An examination of intersectoral literature will equally reveal a desire for perspective or model development. Consider for instance the following extracts:

> *"When men are trying to understand a complex process or system, they do so by seeking a model ..... Without models, explicit or implied there is no understanding".*
>
> Deutsch K.W.
> "Mechanism, Teleology and Mind"
> Philosophy & Phenomenological Research
> Vol. 12, 1951 - 1952

> *"This brings up the question of the role of theoretical frameworks or perspectives in structuring scientific investigation - in selecting our assumptions, metaphors, analogies, and models, and hence pre-forming our observations and how we conceptualize them. I believe that we show little faith in the principles suggested by our own sociology of knowledge, and de-emphasize the role of general theoretical frameworks or models".*
>
> Buckley W.
> "Sociology and Modern Systems Theory"
> Prentice Hall Inc., 1967

In considering the possible adverse effects of de-emphasizing the role of perspectives, reflect on the possible effects of what having a perspective might mean at the level of interaction between the construction industry and its environment. Figure 2 attempts to illustrate such an effect. Here, by adopting, with modification, principles developed by Maruyama,[1] are shown influences in both directions between an agreed theoretical perspective of the construction industry and the performance of the construction industry. In situations where the size of influence in one direction has an effect upon the size of influence in the other direction, and is in turn affected by it, then there is mutual causation. Arrows are used in this diagram to indicate the direction of influence, and the

(1)

Maruyama, Magoroh, "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes", American Scientist, 51 (1963) pp. 164-179.

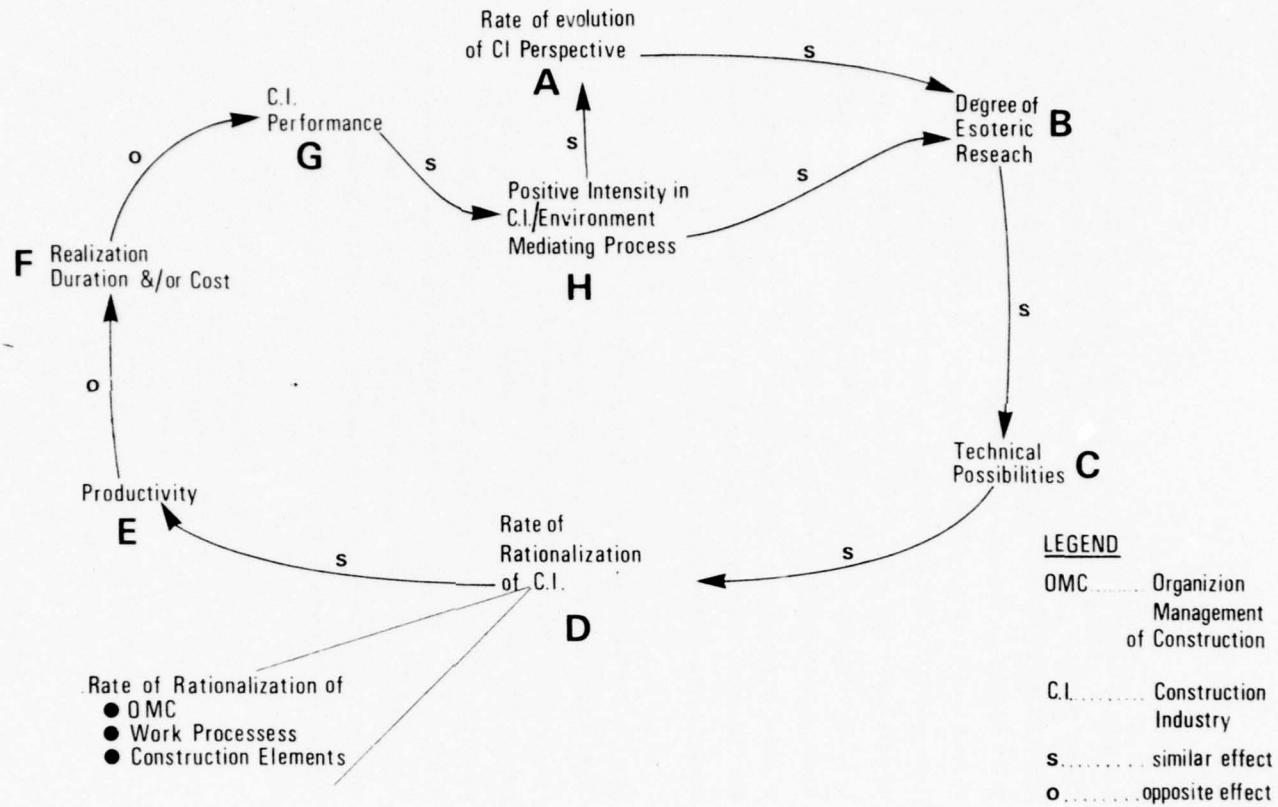
Rate of evolution
of CI Perspective
A
s
Degree of
Esoteric
Reseach
B
C.I.
Performance
G
o
s
s
Positive Intensity in
C.I./Environment
Mediating Process
H
s
F
Realization
Duration &/or Cost
o
s
Technical
Possibilities
C
Productivity
E
Rate of
Rationalization
of C.I.
D
s
s
Rate of Rationalization of
● OMC
● Work Processess
● Construction Elements
LEGEND
OMC ..... Organizion
Management
of Construction
C.I. ..... Construction
Industry
s ..... similar effect
o ..... opposite effect

Fig.2.

symbols "s" and "o" are used to denote "similar effect" and "opposite effect" respectively. For example, the "s" between C and D indicates that an increase in technical possibilities results in an increase in the rate of rationalization of the construction industry, and that a decrease in technical possibilities results in a decrease in the rate of rationalization of the construction industry. On the other hand, the "o" between E and F denotes that an increase in productivity results in a decrease in realization durations and/or costs, and equally that a decrease in productivity results in an increase in realization durations and/or costs. Also in this diagram the influences are looped, indicating that the influence of an element returns to itself through other elements.

Thus, using this diagram we may examine the mutual casual relationships between a theoretical perspective of the construction industry and the performance of the construction industry. We observe that the very existence of a theoretical perspective would result in a greater degree of esoteric research, and this in turn would cause an increase in the illumination of technical possibilities. The increase in the technical possibilities would tend to increase the rate of rationalization of the construction industry by way of increasing the rate of rationalization of one, two or all of the following:

- rationalization of Organization and Management of Construction (OMC). By this is meant improved organization of the planning, manufacturing and assembly processes, more systematic use of electronic data processing and so on,

- rationalization of work processes. By this is meant the mechanisation of work processes amenable to mechanization and the subsequent automation of these mechanized work processes,
- rationalization of construction elements by way of increasing the share of prefabricated parts in constructed facilities.

Increased rationalization of the construction industry would tend to result in its increased productivity and this, in turn, would result in decreased constructed facility realization costs and/or durations. The reduction in constructed facility realization costs and/or durations would result in increased construction industry performance. Increased construction industry performance in the way described would tend to cause an increase in the positive intensity of the construction industry/environment interaction which would result in a greater refinement of the theoretical perspective and this, in turn, would further increase the degree of esoteric research, and so on.

Thus, we observe that each element shown in the diagram has an influence on the other elements either directly or indirectly, and that each element influences itself through other elements. It must also be emphasised that there is no hierarchical causal priority in any of the elements. This is what is meant by mutual causal relationships, a concept that is of extreme importance in this report because within it is the reason of evolution of the construction industry, of its component entities and of the succession of their subordinated components.

What will be observed from this diagram, however, is that if there is no description and theoretical perspective of the construction industry, esoteric research gives way to "piecemeal research" and what develops from that is uncoordinated or random progress. Conversely if we have a generally accepted description and theoretical perspective of the construction industry, piecemeal research gives way to esoteric type research. As the development of a description and perspective of the construction industry is in fact a paradigm, one can say of it, in the words of Kuhn:[2]

"Acquisition of a paradigm and of the more esoteric type of research it permits is a sign of maturity in the development of any given scientific field".

Thus it becomes apparent that the immediate benefits of having a theoretical perspective and description of the construction industry are that they would:

- permit a synthetic means of analysis in a situation where piecemeal analysis is not realistic due to the intricate inter-relationships of entities or components that cannot be treated out of context of the whole,
- provide a means of relating on-going research and discussion on the construction industry and its component entities to a common recognizable reference,

(2)

Kuhn, Thomas S., "The Structure of Scientific Revolutions", Foundations of the Unity of Science, Volume II, No. 2, The University of Chicago Press, Chicago 60637, 1969, p. 11.

- serve as a common reference framework upon which future research and discussion can be based,
- serve as an initial condition from which as we advance in knowledge the theoretical perspective and description will evolve to greater degrees of refinement,
- enable the construction industry to be viewed in terms of information and communication networks linking basic component entities ,
- provide a more informed view of the construction industry,
- be a sign of maturity in construction industry research.

CHAPTER II

THE CONSTRUCTION INDUSTRY – A DESCRIPTION

It is important to remember that contemporary researchers are finding it increasingly difficult to comprehend scientific development as a process of accretion. They are becoming ever more aware of the injudiciousness of persistently seeking permanent contributions of older professions, older systems and older techniques to present vantage. Instead they are beginning to illustrate the historical integrity of these older things to their own time. They are in effect regarding history as more than a repository of anecdote or chronology, they are also using it as a basis for establishing the philosophies, perspectives or conditions that influenced recorded events. Kuhn[3] elucidates this by saying:

"historians of science have begun to ask, for example, not about the relation of Galileo's views to those of modern science, but rather about the relationship between his views and those of his group, i.e. his teachers, contemporaries, and immediate successors in the sciences. Furthermore, they insist upon studying the opinions of that group and other similar ones from the viewpoint - usually very different from that of modern science - that gives those opinions the maximum internal coherence and the closest possible fit to nature. Seen through the works that result, works perhaps best exemplified in the writings of Alexandre Koyré, science does not seem altogether the same enterprise as the one discussed by writers in the older historiographic tradition".

The significance of stating this concept at this point is to emphasise that the description and perspective of the construction industry developed in the ensuing pages are to be judged against current prevailing conditions. When the conditions change, so too must descriptions and perspectives. As an example of this, consider how man's perspective of the world has changed over the years.

(3)
Ibid. p. 3.

The first perspective of the world was produced by the Greek explorer Herodotus, reportedly in the year 450 B.C. and is reproduced here as Figure 3 by courtesy of John Bartholomew & Son Ltd.[4] While the application of this perspective to present vantage is of dubious benefit, it had historical integrity to the earth sciences, to commerce and to exploration in its own time. A second point of significance to be made regarding world perspectives, is that their evolution was not through the initial condition that resulted in their first being, but rather in the subsequent mutual causal processes that amplified this initial condition, built deviations from it and diverged from it. The world's perspectives evolved as a result of such feedbacks obtained from explorations and scientific discovery rather than the initial condition.

Maruyama[5] exemplifies this principle of deviation - amplifying mutual causal processes by describing the development of a city in an agricultural plain:

"At the beginning, a large plain is entirely homogeneous as to its potentiality for agriculture. By some chance an ambitious farmer opens a farm at a spot on it. This is the initial kick. Several farmers follow the example and several farms are established. One of the farmers opens a tool shop. Then this tool shop becomes a meeting place of farmers. A food stand is established next to the tool shop. Gradually a village grows. The village facilitates the marketing of the agricultural products, and more farms flourish around the village. Increased agricultural activity necessitates development of industry in the village and the village grows into a city ...."

"The secret of the growth of the city is in the process of deviation-amplifying mutual positive feedback networks rather than in the initial condition or in the initial kick. This process, rather than the initial condition, has generated the complexly structured city".

(4)

"Atlas of Discovery", Aldus Books, Jupiter Books London.

(5)

Maruyama, Magoroh, "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes", American Scientist, 51 (1963) pp. 166.

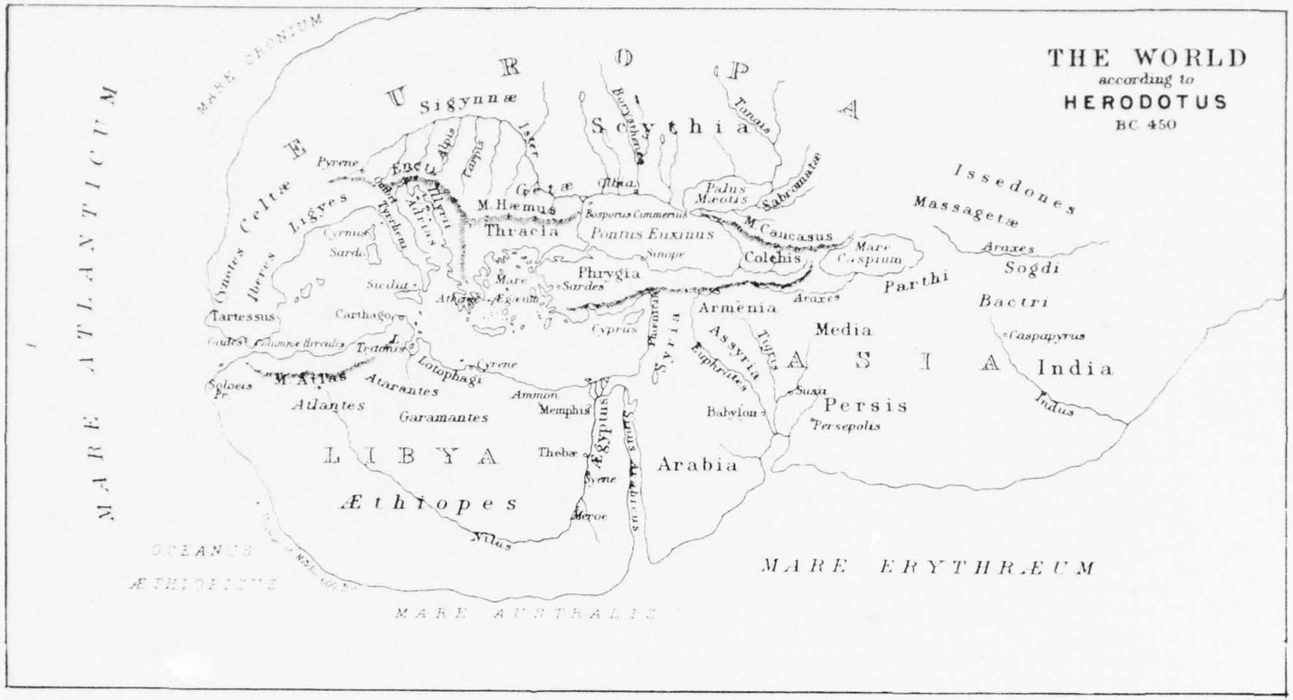
THE WORLD
according to
HERODOTUS
BC 450
EUROPA
ASIA
LIBYA
Scythia
Sigynnæ
Celtæ
Ligyes
Iberes
Cynetes
Tartessus
Pyrene
Thracia
M. Hæmus
Getæ
Pontus Euxinus
Phrygia
Sardes
Sinope
Cyprus
Palus Mæotis
Sabromatæ
Tanais
M. Caucasus
Colchis
Mare Caspium
Issedones
Massagetæ
Araxes
Sogdi
Bactri
Parthi
Media
Armenia
Assyria
Syria
Babylon
Susa
Persis
Persepolis
India
Indus
Arabia
Ægyptus
Memphis
Thebæ
Syene
Meroe
Ammon
Cyrene
Lotophagi
Atarantes
Garamantes
Atlantes
M. Atlas
Carthago
Sicilia
Sardo
Cyrnus
Tyrrheni
Æthiopes
Nilus
Sinus Arabicus
MARE ATLANTICUM
MARE ERYTHRÆUM
MARE AUSTRALIS
OCEANUS
ÆTHIOPICUS

Fig. 3.

In applying this reasoning to the construction industry one can only but conclude that should a historian try to establish when precisely the construction industry came into being he will fail. One can, however, in general terms establish the initial condition or initial kick of the construction industry.

Early man knew only his immediate surroundings - the rivers for fishing, the forests for hunting, water springs for potable water. His home was a primitive shelter, ordinarily self provided and of a temporary nature in keeping with his nomadic life style. He was also embued with a spirit of adventure yielding him an ever-expanding environment. By the year 10,000 B.C. it is claimed[6] that man had discovered the secrets of cultivating crops and of domesticating animals. It is logical to deduce that such discoveries marked the development of permanent farming settlements and the beginning of the agricultural industry.

The cultivation of crops and the domesticating of animals gave rise to a need for tools and equipment. In the satisfying of this need was born the manufacturing industry. The replacement of the nomadic hunting communities with permanent farming settlements amplified the need for the provision of durable shelters and transportation networks. In the satisfying of this need was born the construction industry.

The mental image thus far developed, depicts three industries each having mutual relationships with the other. For example, the agricultural industry requires tools and equipment from the

(6)
"Atlas of Discovery", Aldus Books, Jupiter Books London, P. 8.

manufacturing industry and constructed facilities from the construction industry in order to progress. The construction industry which devotes its time to producing constructed facilities needs:

- the produce of the agricultural industry to sustain itself,
- the tools, plant and equipment from the manufacturing industry to facilitate it in producing its constructed facilities
- orders for its products from both of the other industries in order to remain viable. Without placing orders the other industries would diminish.

Equally the manufacturing industry which is predominantly manufacturing plant, tools and equipment needs:-

- the produce of the agricultural industry to sustain itself,
- constructed facilities from the construction industry in order to facilitate its manufacture,
- orders for its products from both of the other industries in order to remain viable. The other industries without placing orders would diminish and lead to a regression of the development depicted.

It goes without saying that each industry is a consumer of its own products. Developing the progression further we realise that the manufacturing industry also needs supplies of raw materials in order to produce, this is a need that gives rise to a new industry - the mining industry. Thus the progression develops cumulatively through man's conscious response to the demand of certain life

forces where he establishes "initial kicks" to satisfy imminent needs and then the subsequent deviation - amplifying mutual causal processes, cause the established entities to continuously evolve to ever greater degrees of refinement until perhaps they are superseded. Within this progression it becomes apparent that there is a need for co-ordination. For example, the constructed facility support systems are to the mutual benefit of all industries - of society, in fact. Out of the satisfying of this need for co-ordination is born the institution we call government. The satisfying of other needs gave rise to a number of other service organizations and industries coming into being. All these service organizations and industries are sociocultural systems and are related to each other.

The above dialogue of progressive deductive reasoning leads us to a stage of being able to portray in Figure 1 a notional organizational perspective of the sociocultural realm. The perspective is not intended to be definitive regarding the number and type of sociocultural systems in the form of service organizations and industries. For example, the entity services is deemed to include such institutions as educational, military, religious, medical and so on. Equally, under the heading other industries are deemed to be included those industries not separately shown, but which may exist in particular economies such as forestry, fishing and so on. The perspective may also be expanded to include other human organizational groupings such as:- social movements, criminal and delinquent movements, ideational innovation movements and so on. The Figure is sufficient, however, to convey a theoretical perspective of the organizational structure of the sociocultural realm. Within this realm each sociocultural system is treated as being notionally invaginated in a layer that constitutes a boundary

between it and its environment. The reason for this notional invagination is to convey the concept of wholeness and is in no way to be regarded as implying the entity is itself a closed system. On the contrary each entity is an open system and acted upon both without and within, respectively by a constellation of exogenous and endogenous forces.

In this report the approach taken is to treat of sociocultural systems as adoptive systems. This is generally at variance with traditional approaches which base their treatment of sociocultural systems on either a mechanical model or an organic model or a combination of the two. However to base one's treatment of a sociocultural system on a mechanical model is tantamount to suggesting that the interrelationships between the component entities of sociocultural systems are narrowly restricted with few degrees of freedom and are a function primarily of spatial and temporal considerations and the transmission of energy from one component entity to another. In short one could say that to regard a sociocultural system as a mechanical system is to regard it as having a rigid structure.

Equally sociocultural systems cannot be suitably analysed when treated as organic or organismic systems because to do so is to regard them as behaving as organisms. This is tantamount to saying that sociocultural systems like organic systems:

- cannot change their structure and form beyond very narrow limits and remain viable,
- are composed of entities which are related to one another by means of complex physio-chemical energy interchanges.

The third approach currently in vogue is to establish a theoretical framework based on merging the mechanical and organic models. Such an approach results in a theoretical framework which in the words of Buckley[7]

"... is not only questionable in view of their many points of incompatibility, but retrograde in view of modern advances in sociology. These advances should have alerted us to the possibility that the sociocultural level of systems is structurally and dynamically unique and not fundamentally comparable to these other types of systems, despite some point of similarity".

By adopting the adoptive approach provision is made to have regard to the sociocultural systems characteristic of change or elaboration of its structure and form from time to time or even continuously whilst remaining viable in response to internal or external influences. Equally it is an approach that identifies the interrelationships between two or more such systems and between the component entities of such systems as being primarily psychic, involving complex communicative processes of social, economic and technical information exchange. Figure I is an attempt at conveying this notion of interaction between sociocultural systems by showing nexus from each individual entity in the sociocultural realm to all other entities.

In looking at the construction industry as an entity in this large classification called the 'sociocultural realm' it is important to regard it as being a complex, open, structure - elaborating* or negentropic system, composed of interrelated entities, all of which are related directly or indirectly by a causal network. The construction industry as a sociocultural system, is open internally as well as externally, which means that the interchanges amongst its constituent entities may result in significant changes in the nature of these entities themselves and the unorganised aggregation of those changes may significantly change the total system.

(7)

Buckley, Walter, "Sociology and Modern Systems Theory", Englewood Cliffs, New Jersey, Prentice-Hall (1967) p. 7.

* By the term "structure elaborating" is meant that the system responds to environmental intrusions by decreasing in entropy (elaborating or changing its structure and form) in a way that results in its re-establishment at a higher or more complex level.

In a manner similar to that pertaining in the sociocultural realm, the causal networks, allowing internal mediation between the component entities of the construction industry, consist essentially of nexus between these individual entities. These nexus, also, are primarily psychic and involve complex communicative information exchange processes. These information exchange processes depend on some physical base or energy flow. The construction industry also, of course, entertains pure energy interchanges. The situation, therefore, is that the construction industry is part of the socio-cultural realm. The sociocultural realm is composed of a number of individual entities which can be described as sociocultural systems and are recognisable as an industry or as a service organisation. All entities in the sociocultural realm are related to each other by a causal network.

Equally all the individual entities constituting an industry or a service organisation are themselves lower-scale or subordinated sociocultural systems. Each entity in the subordinated sociocultural system is related to the other by a causal network similar to that pertaining in the sociocultural realm.

An important characteristic of these causal networks is that they facilitate feedback control. This feedback control allows both self-regulation and self-direction. This self-regulation and self-direction may manifest itself in the system's structural change and this can be seen as a condition of survival or viability.

Figure 4 is an attempt to illustrate this make-up of the sociocultural realm showing it as a classification of industries and service organisations, where all the industries and service organisations in the classification are in unorganised aggregation. Equally, each

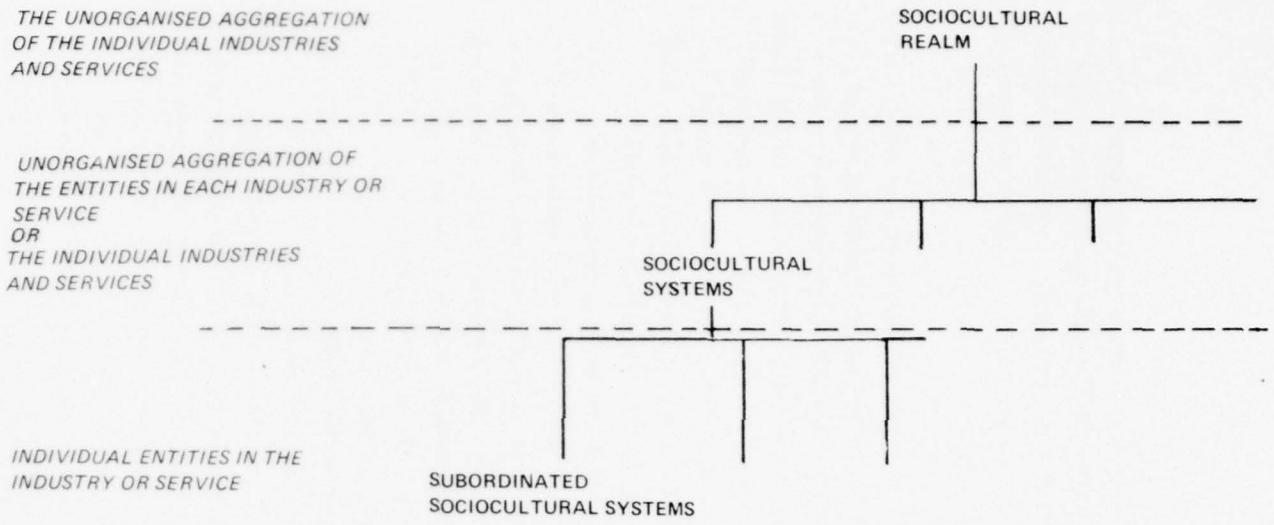
THE UNORGANISED AGGREGATION OF THE INDIVIDUAL INDUSTRIES AND SERVICES
SOCIOCULTURAL REALM
UNORGANISED AGGREGATION OF THE ENTITIES IN EACH INDUSTRY OR SERVICE OR THE INDIVIDUAL INDUSTRIES AND SERVICES
SOCIOCULTURAL SYSTEMS
INDIVIDUAL ENTITIES IN THE INDUSTRY OR SERVICE
SUBORDINATED SOCIOCULTURAL SYSTEMS

Fig. 4.

industry or service organisation is itself a classification of entities that are themselves in unorganised aggregation. The same applies at each successively subordinated level where a number of entities in unorganised aggregation constitute a complex, open, structure-elaborating or negentropic system.

The energy flow upon which the information transmission within those systems or between each system and its environment depends is completely subordinate to the actual form of the information. The actual form of the information, whether it be in written symbols, coded sounds or other form, becomes dynamically related to the entity or entities with which it seeks communication only when it matches or corresponds in some important way with the receiving entities' understanding of the information. In this way, minute quantities of structured energy from one component entity is capable of selectively triggering off a large quantity of activity or behaviour in the receiving component entity or entities and in so doing overcomes limitations of temporal and spatial proximity. This is the case whether the entity to entity communication occurs between the system and its environment or within the system at any of the following levels:

- sociocultural realm level,
- sociocultural system level,
- successive subordinated levels.

This may be exemplified by considering within the construction industry a relationship between Research and Development Institutions and Professional Practitioner Organisations, where, for example, the information transmitted is to advise on the benefits of designing constructed facilities in accordance with a system of dimensional coordination. The information transmitted is going to remain as raw material or energy unless or until the professional practitioner organisations are awakened to the benefits of adopting such a system or

are otherwise motivated to act on it. However once receptive to the information transmitted, the professional practitioner organisations are apt to expend much larger amounts of energy than that contained in the triggering signal, by way of updating office procedure and practice and producing a new range of constructed facility designs and specifications. Equally this latter information when conveyed to construction organisations and component manufacturers will trigger off successively larger amounts of energy by way of modifying assembly processes and manufacturing processes.

Thus it will be observed that the individual component entities of the construction industry are themselves organised, and are highly sensitive to small influences of the correct type to the extent that they are apt to react easily and in so doing are capable of releasing much greater quantities of bound energy than that contained in the triggering signal. In the above example, for instance, the triggering information by the research and development institutions is capable of causing the entire construction industry to reach a new state of rationalisation.

This interpretation of information flow enables it to be regarded as a relationship between entities. In short therefore one can say that the individual component entities of the sociocultural realm, socio-cultural systems and subordinated sociocultural systems are largely autonomous and also maintain intimate and intricate interrelations with their peers and certain environmental entities.

CHAPTER III

THE CONSTRUCTION INDUSTRY – A MORPHOLOGY

The construction industry is a sociocultural system in direct communication with its environment, and within it the process of providing society with constructed facilities is continuously going on. In Chapter II the construction industry was described as being an ensemble of entities all of which are directly or indirectly related in a causal network. The relationships between the entities need to be regarded as exercising a high degree of constraint between the entities in the construction industry. This is so as high degrees of constraint are necessary in order to facilitate the construction industry to develop and adjust to changing conditions in a coherent way. If, for example, this was not the case and the degree of constraint exercised between the entities in the construction industry was extremely loose then there would be a loss of coordination resulting in random development. This might be more fully understood by considering a situation where for example there is a lack of constraint between educational institutions and the other construction industry entities. In such a situation, the educational institutions would most likely be equipping students with a range of skills incompatible with the requirements of those engaging the services of those students when graduated. If on the other hand a high degree of constraint is deemed to prevail between educational institutions and the other entities then the range of skills imparted to the students would most likely highly match the eventual employers' requirements.

The relationship between the entities in the construction industry, it need also be understood, are ordinarily stable within finite time

periods. This is so as the changes in the nature of the construction industry are ordinarily gradual. We do not, for instance, experience a construction industry that is operating largely by means of rationalised traditional craft-based methods and then suddenly, one day, adopts a completely industrialised approach. The changes are gradual involving relatively long transitional periods of many minor changes.

Consideration of the component entities of the construction industry reveals that they may be either simple and stable, or complex and changing. The results of such changes are apt to range from minor property changes in, to complete transformations of, the individual entities. The information transmitted via the communicative network between entities may not only vary in degrees of causal efficacy or priority but may vary in status. By the latter is meant that the interrelations between entities may be mutual or unidirectional. Equally the nature of interrelations may be:

- linear,
- non-linear,
- intermittent.

As the relationships between the entities are stable within finite time periods, and as the entities themselves are classifications for subordinated entities we can depict a theoretical structure and form of the construction industry at particular points on the time scale. In a way this is analogous to the depicting of the status of a business enterprise at any point on the time scale by drawing up its Balance Sheet.

The approach adopted in developing a morphology of the construction industry is to portray its structure and form at a specific instant, as it were, and so give a "static" view. This is done by identifying its

constituent entities and setting them out in relation to one another by means of a causal network. The network although psychic is shown in the morphology so as to give a mental conception. In Chapter IV all entities in the morphological representation are examined in a way that establishes general international consensus as to their purpose and the resources they require in order to fulfil their purpose. In Chapter V the theoretical skeletal perspective or morphological representation is examined in the context of its complex dynamic milieu in a manner that sheds light on the way the causal network allows self-regulation and self-direction of the entities singly and collectively.

Piecemeal research, it was stated in Chapter I, leads to stochastic development. Equally, it must be pointed out that piecemeal analysis of the construction industry is, to a large extent, unproductive. This is so as the construction industry needs to be considered as an adoptive system. It is composed of a number of entities possessing intricate social, technical and economic interrelationships, posing a situation that no entity can be treated out of context of the totality or, as Ashby[8] puts it

"We are beginning to see that complexity in major degree is not an insuperable barrier to knowledge, provided it is tackled in the appropriate way. The way NOT to tackle such a system is by analysis, for this process gives us only a vast number of separate parts or items of information, the results of whose interaction no one can predict. If we take such a system to pieces, we find that we cannot reassemble it".

Unfortunately until now there has been no clear concept, no clear perspective of the totality of the construction industry in terms of broad general universally applicable descriptors, and so, its examination has been in the way Ashby has suggested it should not be done.

(8)

Ashby, W.R., "The Effects of Experience on a Determinate Dynamic System", Behavioural Science I (1956) pp. 35-42.

Referring back to Figure I we observe the construction industry as an entity in the sociocultural realm. Here we wish, in full acknowledgement of this context, to develop a perspective of the construction industry as a specific sociocultural system. We can do this by focussing on the entity construction industry as depicted in Figure I and reproducing it in magnified form as shown in Figure 5.

In this figure it will be observed that the author has indulged in "diagramatic licence" for the purpose of emphasising certain points. To begin with, the construction industry has been magnified in size by focussing in on it to the extent that all other entities in the sociocultural realm have been excluded. Nevertheless, the construction industry's complete environment which contains all those excluded entities, is portrayed as enveloping the industry. There is thus an anomaly in the incompatibility of relative scales, and in the amount of detail shown, but this can be justified on the grounds that once the anomaly is explained the figure portrays the concept that the construction industry as a complete industry is in interplay with an environment we can conceptually comprehend. However, this is not the complete picture of the construction industry's environment. The sociocultural realm has, in its environment, man. It must be remembered that the construction industry came into being to serve man. Its function was to provide shelter and support systems. Today it is often thought of as being:

- an economic indicator,
- an employer of people,
- a supplier of investment goods,
- a consumer of materials and services.

It appears however, as will be revealed in the next chapter, that the construction industry is still the servant of man and that today's concept by some, as expressed in the above terms, indicates

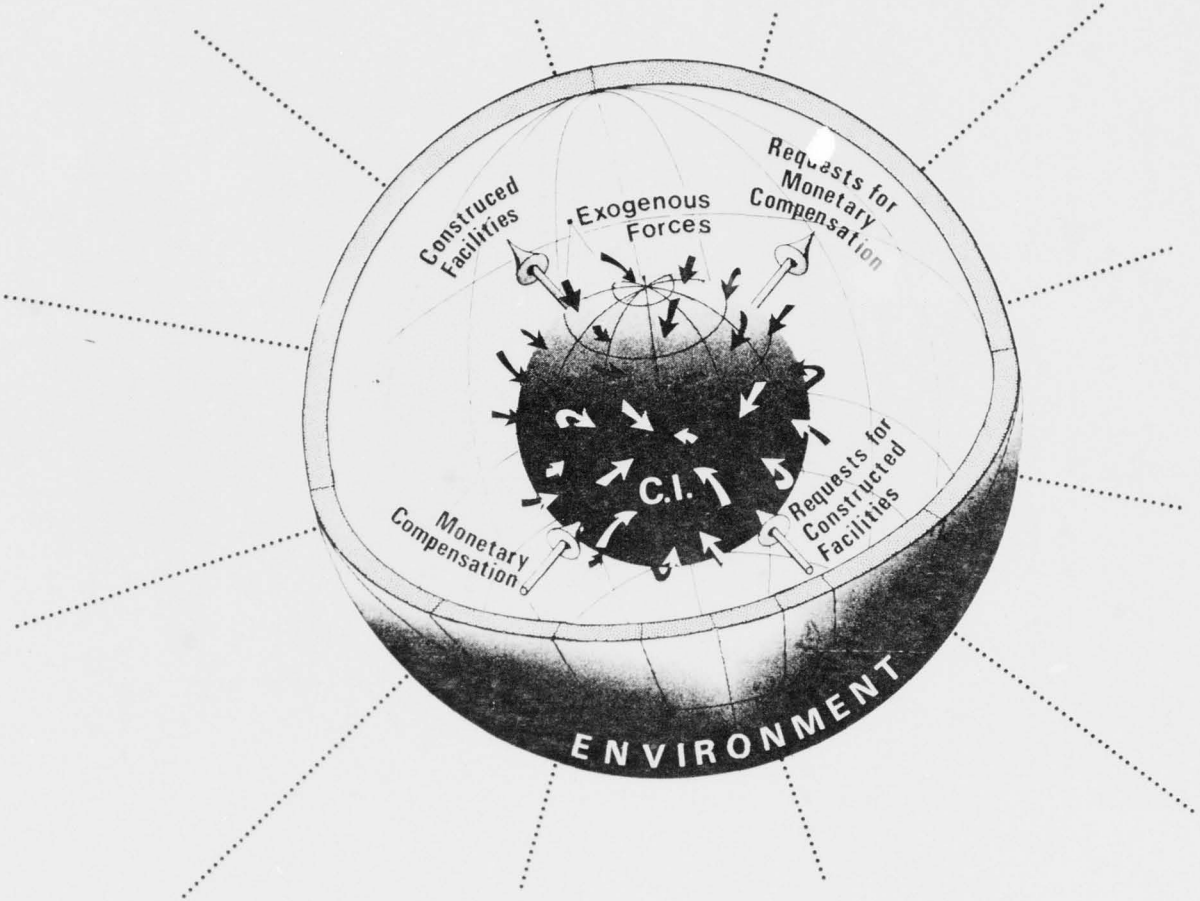
Constructed Facilities
Exogenous Forces
Requests for Monetary Compensation
C.I.
Monetary Compensation
Requests for Constructed Facilities
ENVIRONMENT

Fig. 5.

confusion surrounding its true purpose. Such concepts reveal that:

- its function is confused with parameters that would indicate degree of function achievement,
- its function is confused with means of operation or with constraints imposed on means of operation,
- its function is thought of as means of providing sound investment goods to yield good return with low risk,
- its function is to provide a market in which goods and services may be traded.

If on the other hand it is viewed from the point of view of its necessity, then man in relation to it may be considered as a:

- medium or agent that contributes certain inputs to the industry or, more specifically, to entities within it, that employs or otherwise engages him. He fulfils a similar role for all the other industries and service organisations in the sociocultural realm. Thus his role can take the form of his being a medium or communicating agent for any industry or service organisation for the purpose of procuring its products or services. Equally he may serve as a medium or communicating agent between the different entities in the particular sociocultural system in which he is engaged. His role may also be as a provider of skills and as a source of energy,
- domestic consumer of the industry's products or recipient of its services.

The construction industry environment, therefore, speaking at the sociocultural level, consists of:

- all other entities or sociocultural systems in the sociocultural realm, and
- man

On referring again to Figure 5 it will be readily accepted that the majority of the constellation of exogenous forces acting on the construction industry are themselves endogenous to the sociocultural realm. Also in this anomalous state, the diagram conveys the notion of wholeness of our reference. Finally, it does not depict in the interest of clarity the notional existence of communicative channels extending from the construction industry to other entities in the socio-cultural system.

The continuous action of the dichotomy of forces acting on and within the construction industry manifests two concomitant sequences of activities. One sequence of activities is related to the construction industry's self-regulation and self-direction and the other is concerned with its primary and necessary secondary functions' fulfilment.

The nature of the activities related to the construction industry's self-regulation and self-direction will be considered in some detail in Chapter V. However as portrayed in Figure 5 they need be considered as:

- Client and resource supplier demands. The demands referred to here are those that are of a general social, economic and technical nature as distinct from those directly related to the fulfilment of a specific request for a specific constructional facility. Examples of the type of demand intended for consideration here include:
  - speed of assembly,
  - value for money,
  - duration of credit terms,
  - limitations on the range of product sizes.

- Competitive activities: These usually take the form of other sociocultural realm entities competing for a limited supply of resources. The main resources being:
  - materials,
  - labour,
  - money,
  - equipment,
  - work space.
- Regulatory group activities: These usually take the form of governmental, social and ideational movement activities. An example of such activities would be trade union action. Whereas the bulk of trade union activities affecting the construction industry is endogenous to it, certain of the activities are exogenous and these can significantly affect the construction industry's main functional operations.

As an illustration of this last point, consider a situation in which industrial unrest prevails in a sociocultural system entity whose primary function it is to manufacture a basic construction industry material such as cement. Suppose also that cement manufacturers are deemed to be part of the manufacturing industry, as to whether they consider themselves part of the construction industry or the manufacturing industry is, in reality, a point of little consequence. However, industrial action by a trade union in such a manufacturing organisation, particularly if prolonged, could virtually starve the construction industry of this product resulting perhaps in bringing it to a virtual standstill. In the Republic of Ireland, for example, it is mandatory in order to manufacture or import cement to obtain a licence. The importation licence is restricted to cement types not being indigenously manufactured and there is only one cement

manufacturer in operation in the country. The situation is somewhat compounded by the fact that the main transporter of this product from the manufacturing industry to the construction industry is by the national transport organisation. Thus industrial unrest in either the cement manufacturers or the national transport organisation or both can have a significant effect on the construction industry even though both organisations are in other sociocultural systems. Another example of a similar nature can be gleaned by considering a situation in which industrial unrest in an organisation within a sociocultural system other than the construction industry prevails. Suppose in this situation that the trade union representing those in dispute also represented some personnel in a construction industry organisation enjoying industrial harmony. It sometimes happens in such a situation that those enjoying industrial harmony would take sympathetic industrial action not because they have a grievance with their own employer, the employer of those in dispute, the public or the government but because they happen to be members of the same union representing those in dispute in another sociocultural system. Other examples of such activities are government legislation pertaining to such things as change in units to be used for weights and measurements and such like. Restriction or injection of funds by financial institutions are other examples.

The specific sequence of activities that take place between the construction industry and its environment relating directly to its primary and necessary secondary functions' fulfilment can be identified as:

- requests from clients, in the environment, to the construction industry for specific constructed facilities,

- the handing over of these constructed facilities by the construction industry to the client,
- requests from the construction industry to client for monetary compensation for its efforts. Money may be considered as being the sustaining agent of the construction industry,
- the handing over of this monetary compensation by the client to the construction industry.

Stating that requests come only from clients in the environment poses the question of how one should treat of a situation where the request in fact comes from an entity within the construction industry itself, for example, a professional practitioner requesting new offices. In this situation it is best to treat of the request as coming from the environment rather than within itself, even though in such a situation the client may engage his own services. One must remember that, theoretically, the construction industry is the vehicle for providing constructed facilities, and, as such, is available to constituent entities within it that require such a product. There is ample precedent for this procedure in the domain of financial accounting where, under the concept of "accounting entity" one is obliged to consider the business entity as being distinct from the persons associated with these entities, and to record in the accounts only those aspects of a transaction that affect the business and not the aspects that affect the people who own, operate or are otherwise associated with the business.

Equally in describing a morphology of the construction industry, and in describing the primary and necessary secondary functions of it and its component entities one is obliged to consider the morphology and the functions as being distinct from the persons associated in any way with those items. Furthermore, one is obliged to include in

the descriptions only those aspects that affect the morphology and the functions and not those aspects that affect the people who are in any way associated with them. Failure in this regard can only lead to confusion.

The sequence of activities identified above specifically relates to the construction industry's fulfilment of its primary and necessary secondary functions. However, in order to carry out these functions the construction industry's component entities are organised into systemic relationships. These same relationships also permit the construction industry to monitor and adjust to internal and external influences manifesting processes of self-regulation and self-direction. However, the organised systemic relationship of the component entities do have structure and form. Figure 6 is an attempt at identifying the component entities and causal network for the construction industry and at depicting for them a structure and form in a way that conveys the notion of wholeness. As such it is called a Morphological Representation of the construction industry.

From this Figure it will be observed that the construction industry has, for convenience purposes, been divided up into three generic processes, namely:

- a basic process,
- a managerial process,
- a support process.

Also the channel of communication between the construction industry and its environment facilitating the activation of the sequence of activities concerned with primary and necessary secondary function fulfilment, which were identified in Figure 5, is shown by means of a nexus from the managerial process to the client.

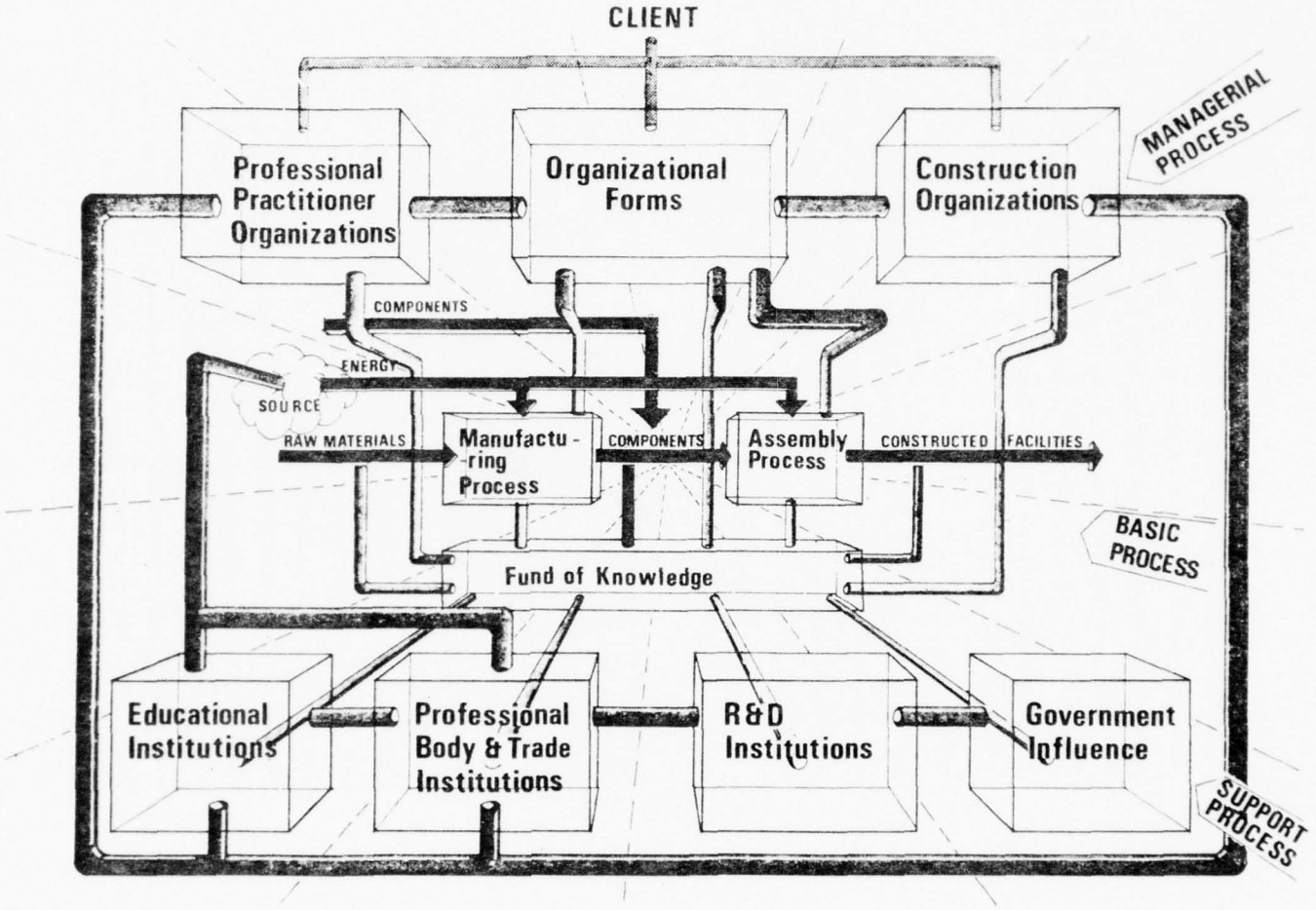
CLIENT
Professional Practitioner Organizations
Organizational Forms
Construction Organizations
MANAGERIAL PROCESS
COMPONENTS
ENERGY
SOURCE
RAW MATERIALS
Manufactu - ring Process
COMPONENTS
Assembly Process
CONSTRUCTED FACILITIES
BASIC PROCESS
Fund of Knowledge
Educational Institutions
Professional Body & Trade Institutions
R&D Institutions
Government Influence
SUPPORT PROCESS

Fig. 6.

It must be emphasised that the interrelations between the component entities of the construction industry and between the construction industry and its environment via the nexus identified in Figures I and 6 involves self-regulating loops of the type referred to in Figure 2. This feedback is fundamental to the complex organisation and dynamics of the construction industry which involves learning, goal-seeking and evolution.

The Basic Process

This process, represented by the central plane of Figure 6, performs the basic transfer function by the construction industry, of transforming materials and components with the aid of energy into constructed facilities. It consists essentially of two specific processes:

- a manufacturing process, and
- an assembly process.

The manufacturing process is not to be confused with the manufacture of components by the manufacturing industry. It represents the "on location" or "on site" manufacture by the construction industry of certain of its materials and components as, for example, site-made concrete and those off-site manufacturing processes exclusively carried out for the construction industry such as ready mixed concrete. In short, therefore, the manufacturing process illustrated in Figure 6 represents the transformation of raw materials with the aid of energy, into particular materials and components. In order to provide a crude line of demarcation between the construction industry and the manufacturing industry, should such a line be necessary, it is perhaps worth temporarily regressing or suspending our theory and taking a morphostatic view. Figure 7 is one such attempt which although identifying a break between the two industries, causes one to query the technical premise of such a boundary. However, it does serve

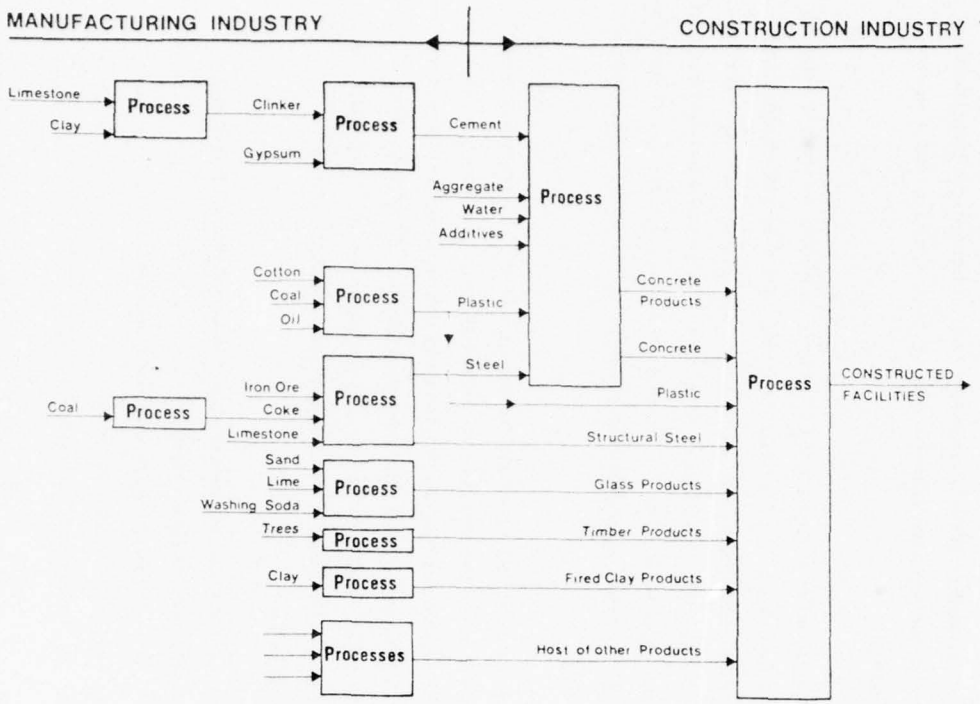
MANUFACTURING INDUSTRY
CONSTRUCTION INDUSTRY
Limestone
Clay
Process
Clinker
Gypsum
Process
Cement
Aggregate
Water
Additives
Process
Cotton
Coal
Oil
Process
Plastic
Concrete
Products
Concrete
Steel
Coal
Process
Iron Ore
Coke
Limestone
Process
Plastic
Process
CONSTRUCTED
FACILITIES
Structural Steel
Sand
Lime
Washing Soda
Process
Glass Products
Trees
Process
Timber Products
Clay
Process
Fired Clay Products
Processes
Host of other Products

Fig.7.

the purpose of drawing attention to our area of concern. Nevertheless, having done so, it is necessary to be re sensitised to the fact that there is a network of social, economic and technical interrelationships between the construction industry and all other entities in the socio-cultural realm.

The assembly process depicted in Figure 6, transforms, with the aid of energy, these on and off site manufactured materials and components and other materials and components imported directly from the manufacturing industry, into constructed facilities. It must be pointed out that the energy referred to here may consist of anything in the range from that produced by manual labour to that produced by the most sophisticated machinery.

The source of the raw materials for the on and off site manufacturing processes and for the components imported from the manufacturing industry varies according to the construction organisations and sub-contracting organisations' procurement policies. They may, for example, come directly from the manufacturers or they may come via distributors in the form of wholesalers or builders' providers.

The Managerial Process

This generic process, represented by the upper plane of Figure 6 consists of three entities, namely:

- Professional practitioner organisations.
- Organizational forms.
- Construction organisations.

Professional practitioner organisations are essentially appropriators of skills to specific organizational forms. From the point of view of the individual professional practitioner office this is ordinarily done

by their engaging persons competent in the use of specific skills. These persons would usually have proven their competence to an agency external to themselves such as a university or a professional institution. Once the persons are recruited they are then assigned to specific organizational forms where they work with other persons, each possessing different, or indeed, sometimes similar skills, but all working to orchestrate the construction of a particular constructed facility or group of constructed facilities. The term "professional practitioner organisations" as used here is deemed to include any professional design divisions within organisations that provide their own design service.

Equally the construction organisations appropriate their skills to specific organizational forms. However, as the construction organisations are responsible for setting up both the on-site manufacturing and assembly processes, in addition to appropriating their skills to specific organizational forms, they also have to appropriate their factors of construction to specific projects. The term "construction organisations" as used here, is deemed to include construction departments where organisations provide their own construction services.

In the above appropriation of skills, it is not uncommon for the possessors of specific skills to be assigned to more than one organizational form. Equally, in some instances, such as package deal or turnkey operations, both designers and constructors may be drawn from the same construction organisations.

The organizational form entity, unlike the other two, rarely, if ever exists as a separate business. Each organizational form comprises some particular combination of skills, as appropriated by both the professional practitioner organisations and construction organisations,

for the purpose of orchestrating a particular project. The existence of organizational forms ordinarily terminates on completion of its project. Organizational forms may be thought of, therefore, as a convenience term used to identify the particular group of designers and construction organisers whose task it is to orchestrate the construction of a particular constructed facility or group of constructed facilities.

The Support Process

This generic process represented by the lower plane of Figure 6 consists of five entities, namely:

- educational institutions,
- professional body and trade institutions,
- research and development institutions ,
- government influence ,
- fund of knowledge.

The educational institutions, as far as the construction industry is concerned, endeavour to to fulfil the function of educating and training people to achieve a publicly recognised occupational competence. Equally they undertake research and disseminate their researched findings.

Professional body and trade institutions have as their function the provision of an identity and the setting and regulation of competence standards for their members.

Developing, reorganising and applying knowledge and ensuring its availability to all entities within the system and influencing the evolution of the construction industry is the prime concern of the research and development institutions.

The Government has a definite role to play within the system. This role takes many forms and ranges from providing direct injections to the sustaining agent or monetary flow to making it mandatory for certain elements within the system to comply with specific information within the fund of knowledge. The fund of knowledge is essentially a convenience term used to identify the repository of all information available to all entities in the construction industry. Some of this information is for mandatory compliance as, for example, planning laws and building regulations, while some of the information is for optional use, as for example, national building specifications and project scheduling methods. The information in the fund of knowledge is deemed to include:

- corticaly imprinted information and
- information stored in extrasomatic sociocultural depositories.

Thus the construction industry has a structure and form that can be described in terms of identifiable entities all of which must be regarded as open systems directly related to one another through a causal network. This causal network may be thought of as a psycho-socially developed and supported web of communicative interrelations having varying degrees of permanence and, as such, they give to the construction industry a completeness of structure. By permanence is meant information interchanges that become repetitive as these give to the industry a relative stability in social, economic and technical interrelationships. Equally it must be understood that the construction industry itself as a system must be thought of as an entity in a larger system, a system called the sociocultural realm.

CHAPTER IV

THE CONSTRUCTION INDUSTRY – FUNCTION AND PERFORMANCE

It has been stated in Chapter III that the individual component entities of the construction industry are organised into systemic relationships. This implies that the unorganised aggregation of the component entities is something more than the numerical addition of the individual component entities. This point becomes more obvious when we consider that the organisation of the component entities imparts to the aggregate, characteristics that are not only different from, but often not to be found in the individual component entities when unorganised. Buckley[9] describes this concept as follows:

"... if social groups are not 'real entities' then neither are individual organisms, organs, cells, molecules or atoms, since they are all 'nothing but' the constituents of which they are made. But this 'nothing but' hides the central key to modern thinking - the fact of ORGANIZATION of components into systemic relationships. When we say that 'the whole is more than the sum of its parts', the meaning becomes unambiguous and loses its mystery: the 'more than' points to the fact of ORGANIZATION which imparts to the aggregate characteristics that are not only DIFFERENT from, but often NOT FOUND in the components alone; and the 'sum of the parts' must be taken to mean, not their numerical addition, but their unorganized aggregation".

Sensitised to this fact, in this chapter are examined the primary function, the necessary secondary functions and the performance parameters for assessing the degree of function fulfilment for the construction industry as a whole and for each of its component entities. In this examination one must be ever conscious that the structure of the construction industry is apt to discrete or continuous change without dissolution of the system. This needs to be considered at a number of levels:

- at the level of the construction industry as a system where its structure is examined in terms of its entities,

(9)

Buckley, Walter, "Sociology and Modern Systems Theory", Englewood Cliffs, New Jersey, Prentice-Hall (1967).

- at the level where each entity of the construction industry is examined as a system in its own right, and its own structure is examined in terms of its component entities,
- at successive subordinated levels.

In addition to determining a consensus as to what are the primary function, necessary secondary functions and performance parameters of the construction industry and its component entities, it was also decided to ascertain a consensus as to what are the inputs to, and outputs from, the construction industry and each of its component entities that possess processing attributes. The method adopted in this determination was to formulate a questionnaire and dispatch it sequentially to two respondent groups. The first group of respondents, called the Ireland/UK Research Consortium, consisted mainly of the Irish and United Kingdom members of Working Commission 65 of CIB - The International Council for Building Research Studies and Documentation. The second group comprised all CIB W-65 members.

The procedure adopted was that the author prepared a questionnaire for a meeting in UMIST, the University of Manchester Institute of Science and Technology, Manchester, United Kingdom, to which all members of the Ireland/United Kingdom Research Consortium were invited. The draft questionnaire was considered and agreed, and all attendees committed themselves to responding. The author then processed these responses for the group. A second meeting of the group was convened in An Foras Forbartha, The National Institute for Physical Planning and Construction Research, Dublin, Ireland. At this meeting the synthesised response was debated and consensus reached. The questionnaire, then accompanied by the Ireland/United Kingdom consensus response, and called at this stage Questionnaire No 2, was dispatched to the second group of potential respondents.

The responses from the CIB W-65 members were then synthesised by the author and incorporated in a draft report which was presented for consideration to the Working Commission at its 5th meeting in Technion, Israel Institute of Technology, Haifa, Israel on 1978 November 3. The author in accordance with the wishes of the meeting then undertook to prepare a final draft and forward it to Dr L.R. Shaffer, Coordinator, CIB W-65 for distribution to the Commission and for publication in NTIS, National Technical Information Service, Department of Commerce, United States of America.

Figure 8 illustrates the consensus international response to Question No 1 regarding the primary function and necessary secondary functions of the component entities of the construction industry. The international consensus response as represented by the members of the International Council for Building Research and Documentation Working Commission 65 formulates Table II.

In drafting the questionnaire it was considered judicious to impose a certain discipline on respondents. The reason for this was that had no discipline been imposed, responses would most likely have been in the form of sentences and perhaps paragraphs and as such would be inclined to confuse "function" with "activity", with "constraints", with "performance parameter" and with "incentives". Equally, long narratives would be difficult to synthesise and compare one with another. The discipline imposed was that functions be described by means of a two-word abridgment in accordance with the principles of value analysis/engineering.[11 & 12]

(10)

Boland, Thomas F., "Evaluation of Organizational Forms Using Value Analysis/Engineering", Proceedings of the CIB W-65 Symposium on Organization and Management of Construction, US National Academy of Sciences, Washington DC, USA, May 19-20, 1976.

(11)

Boland, Thomas F., "Value Analysis/Engineering, Its General Use and Some Applications to the Construction Industry", Technology Ireland December 1975, pp. 7-20.

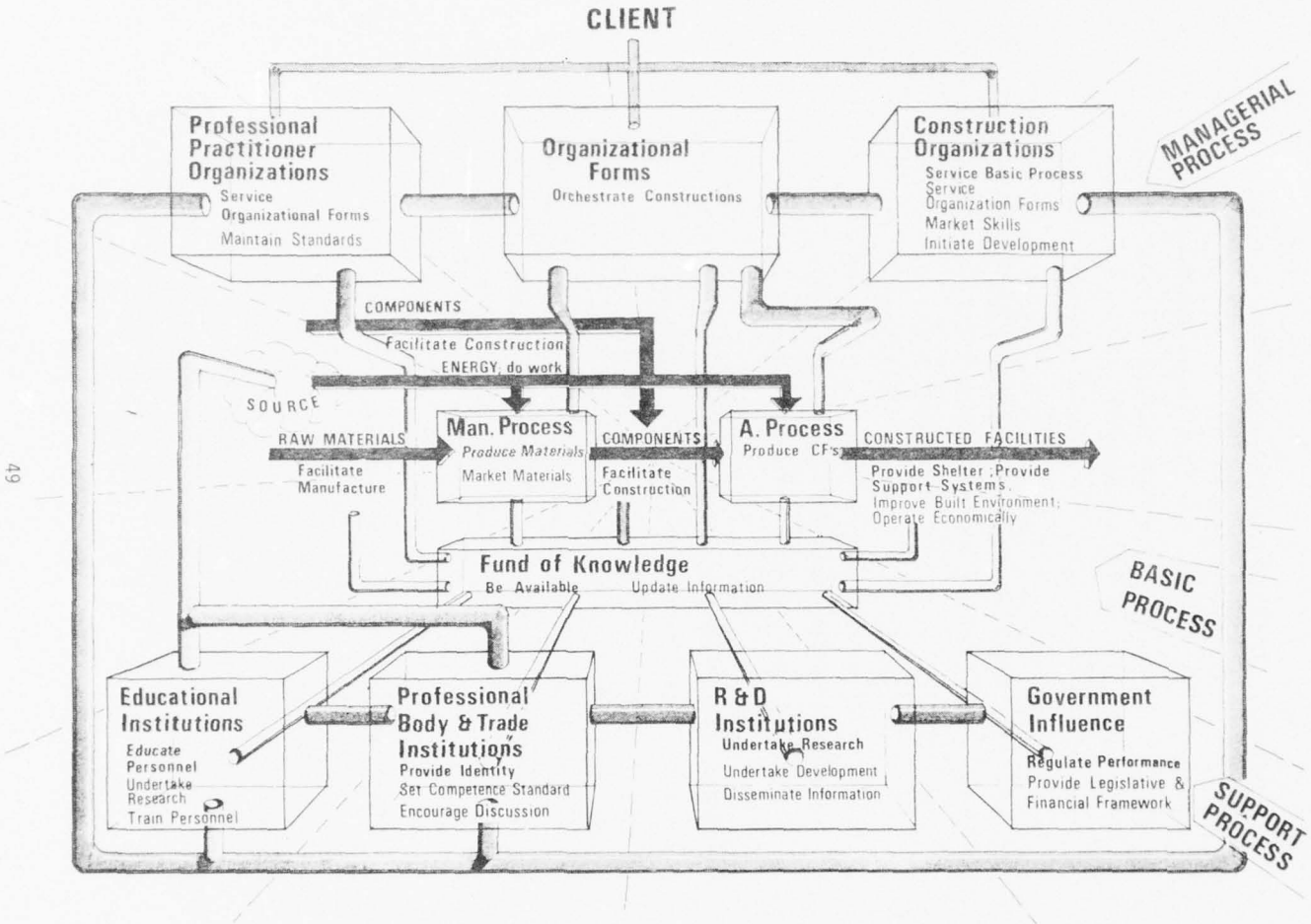
CLIENT
Professional Practitioner Organizations
Service
Organizational Forms
Maintain Standards
Organizational Forms
Orchestrate Constructions
Construction Organizations
Service Basic Process
Service
Organization Forms
Market Skills
Initiate Development
MANAGERIAL PROCESS
COMPONENTS
Facilitate Construction
ENERGY, do work
SOURCE
RAW MATERIALS
Facilitate Manufacture
Man. Process
Produce Materials
Market Materials
COMPONENTS
Facilitate Construction
A. Process
Produce CF's
CONSTRUCTED FACILITIES
Provide Shelter ;Provide Support Systems ;
Improve Built Environment;
Operate Economically
Fund of Knowledge
Be Available
Update Information
BASIC PROCESS
Educational Institutions
Educate Personnel
Undertake Research
Train Personnel
Professional Body & Trade Institutions
Provide Identity
Set Competence Standard
Encourage Discussion
R & D Institutions
Undertake Research
Undertake Development
Disseminate Information
Government Influence
Regulate Performance
Provide Legislative & Financial Framework
SUPPORT PROCESS

Fig. 8.

The procedure for defining a function in accordance with established value analysis/engineering procedures is to use two words, a verb and a noun. The simplicity of this approach is deceptively easy. In order to select the proper two-word description for a function one needs to have a comprehensive understanding of the entity under scrutiny. Functional descriptions are not necessarily correct just because they seem to be the most obvious. Equally one may use a series of two-word abridgment to describe the functions of each entity, however it is only one of these that can be descriptive of the primary function of the entity. The primary function is deemed to be the specific purpose that must be achieved by the entity, all the other functions that must be accomplished by the entity are called "necessary secondary functions". While these necessary secondary functions are important, they are not controlling.

The two-word abridgment of a verb and a noun, proved most valuable in analysing responses to the questions posed in the questionnaires used in this study. A few respondents did not adhere to the discipline imposed and used a sentence to describe functions. This was not concise enough and showed confusion in the mind of the respondent as to what constituted a function. Respondents also found that for some entities the primary function was what they considered as a secondary function.

A stipulation imposed on respondents was that in selecting the noun in the two-word abridgment care should be taken to ensure that it was measurable or capable of quantification. For example, the primary function of the construction industry may be described as "provide facilities". The term facilities, however, is not readily measurable. An improved definition might be "provide constructed facilities". Here an adjective is used to condition the noun and lends the subject

suitable to quantification. This modification of the two-word abridgment proved necessary in cases where the selection of the proper two-word abridgment proved difficult. In short, a relaxation of the rule was permitted in difficult cases to the extent that an additional adjective could be used to condition the noun.

The primary function of an entity is deemed to be the specific purpose that must be achieved by the entity. It answers the question "What must this entity do?" The necessary secondary functions are deemed to be those other functions that must be accomplished by the entity. They answer the question "What else is it necessary for this entity to do?"

The performance parameters are deemed to be indicative of suitable criteria to assess the degree to which entities achieve function fulfilment.

In the morphological representation certain generic processes are used as a convenience of categorisation and as such do not have a specific function to perform. These generic processes are:

- the basic process,
- the managerial process,
- the support process.

Certain other convenience terms are also used for the purpose of identifying entities that present difficulty in conception but which do have a function or functions to fulfil, such as:

- Organizational Form which is largely intangible as an entity,
- Fund of Knowledge which in reality represents the infinity of information stowed for retrieval in all depositories.

TABLE II

ENTITY	FUNCTIONS		PERFORMANCE PARAMETERS
	NAME	TYPE	
CONSTRUCTION INDUSTRY	PROVIDE CONSTRUCTED FACILITIES	P*	% OF GNP[1] TO BE ABOVE A SPECIFIC LIMIT. % OF GFCF [2] TO BE ABOVE A SPECIFIC LIMIT. CHANGES IN THE RELATIONSHIP OF CONSTRUCTION INDUSTRY PRODUCTIVITY TO OTHER INDUSTRIES TO BE WITHIN ACCEPTABLE LEVELS FOR EQUIVALENT LEVELS OF INVESTMENT.
	MAINTAIN[3] CONSTRUCTED FACILITIES	NS**	TREND IN MONETARY VALUE OF GRANTS AND LOANS BY LOCAL AUTHORITIES FOR CF+ MAINTENANCE TO BE WITHIN A TOLERABLE RANGE. TREND IN MONETARY VALUE OF FUNDS BY FINANCIAL INSTITUTES FOR CF MAINTENANCE TO BE WITHIN A TOLERABLE RANGE. RATIO OF EXPENDITURE ON EMERGENCY REPAIRS TO TOTAL MAINTENANCE TO BE WITHIN A SPECIFIC RANGE. PREVENTATIVE MAINTENANCE COSTS AS A % OF TOTAL MAINTENANCE COSTS TO BE WITHIN A SPECIFIC RANGE. EXPENDITURE ON CF MAINTENANCE AS A % TOTAL INVESTMENT TO BE WITHIN A TOLERANCE RANGE. NATIONAL INVENTORY OF CONSTRUCTED FACILITIES *TO BE MAINTAINED PER HEAD OF POPULATION.* AVERAGE AGE OF BUILDINGS NOT TO FALL.
	REHABILITATE CONSTRUCTED FACILITIES	NS	PERCENT OF SUBSTANDARD CF TO TOTAL CF POPULATION NOT TO FALL BELOW A CERTAIN FIGURE
	CONVERT CONSTRUCTED FACILITIES	NS	PERCENT OF CF PERFORMING FUNCTIONS DIFFERENT THAN THOSE FOR WHICH ORIGINALLY INTENDED TO TOTAL CF POPULATION TO FOLLOW AN ACCEPTABLE TREND
MANAGERIAL PROCESS BASIC PROCESS SUPPORT PROCESS	THESE ARE CONVENIENCE TERMS USED FOR THE PURPOSE OF CATEGORIZING ENTITIES AND, AS SUCH, DO NOT HAVE A SPECIFIC FUNCTION TO PERFORM.		

* P = Primary ** NS = Necessary Secondary +CF = Constructed Facilities

(1) GNP = Gross National Product

(2) GFCF = Gross Fixed Capital Formation

(3) 'Maintenance' includes 'repair'. In other words all non-preventative maintenance constituting 'repair'.

TABLE II (Continued)

ENTITY	FUNCTIONS		PERFORMANCE PARAMETERS
	NAME	TYPE	
ORGANIZ– IONAL FORM	ORCHESTRATE[4] CONSTRUCTION	P	DISCREPANCY IN RATIO OF SCHEDULED EXPENDITURE PER UNIT TIME TO ACTUAL EXPENDITURE PER UNIT TIME. % OF CF REALISATION COST OVERRUN TO ESTIMATE COST TO BE WITHIN ACCEPTABLE TOLERANCE LEVELS. ORGANIZATIONAL FORM COST/TOTAL COST RATIO TO BE WITHIN A CERTAIN RANGE. % OF COST VARIATIONS TO INITIAL ESTIMATED COST TO BE WITHIN ACCEPTABLE LEVELS. DEGREE TO WHICH CF REALIZATION MATCHES PLANNED PERFORMANCE PARAMETERS
PROFESSIONAL PRACTITIONER ORGANIZ– ATIONS	SERVICE ORGANIZ- ATIONAL FORM	P	DEGREE WITH WHICH SKILLS AVAILABLE CAN BE MATCHED TO THE WHOLE RANGE OF CLIENT BRIEF REQUIREMENTS THAT NEED TO BE DEALT WITH IN ORGANIZATIONAL FORM SHOULD NOT FALL BELOW A CERTAIN LEVEL.
	MAINTAIN STANDARDS	NS	CHANGES IN ANNUAL MONETARY TURNOVER AS A PROPORTION OF INDUSTRY TURNOVER.
CONSTRUCTION ORGANIZ- ATIONS	SERVICE BASIC PROCESS	P	DEGREE TO WHICH RESOURCES CURRENTLY AVAILABLE MATCH THE PROJECTED NEED SHOULD NOT FALL BELOW A CERTAIN LEVEL.
	SERVICE ORGANIZ- ATIONAL FORM	NS	DEGREE WITH WHICH SKILLS AVAILABLE CAN BE MATCHED TO THE WHOLE RANGE OF PROJECT REQUIREMENTS THAT NEED TO BE DEALT WITH IN ORGANIZATIONAL FORM SHOULD NOT FALL BELOW A CERTAIN LEVEL.
	MARKET SKILLS	NS	CHANGES IN ANNUAL MONETARY TURNOVER AS A PROPORTION OF INDUSTRY TURNOVER
	INITIATE DEVELOP- MENT	NS	CHANGES IN UNIT COST OF CONSTRUCTION TO FOLLOW SOME ACCEPTABLE TREND

(4) Orchestrate is deemed to include design, organize and supervise. The supervisory costs encompass all those directly under the authority of Organizational Form, including project manager, resident engineer, resident architect and Clerk of Works.

TABLE II (Continued)

ENTITY	FUNCTIONS		PERFORMANCE PARAMETERS
	NAME	TYPE	
EDUCATIONAL INSTITUTIONS	EDUCATE PERSONNEL	P	EFFICIENCY OF INDUSTRY AS REFLECTED IN IMPROVED PRODUCTIVITY TRENDS.
			DEGREE TO WHICH VOCATIONAL AND MANAGEMENT SKILLS MATCH INDUSTRY'S DEMANDS BOTH QUANTITATIVELY AND QUALITATIVELY.
	UNDERTAKE RESEARCH	NS	RATIO OF CONTRACT RESEARCH INCOME TO TOTAL INCOME TO BE ABOVE A CERTAIN FIGURE.
			TREND IN RATIO OF OVERSEAS APPLICANTS TO NATIONAL APPLICANTS.
			NUMBER OF PATENTS AND LICENCES TO FOLLOW AN ACCEPTABLE TREND.
			RATIO OF STAFF ON BASIC RESEARCH TO STAFF ON CONTRACT RESEARCH TO BE ABOVE A CERTAIN FIGURE.
			DEGREE TO WHICH RESEARCHED FINDINGS ARE EMULATED.
	TRAIN PERSONNEL	NS	DEGREE TO WHICH TRAINING GRANTS ARE UTILIZED TO BE ABOVE A CERTAIN LEVEL
PROFESSIONAL BODY INSTITUTIONS	PROVIDE IDENTITY	P	DEGREE TO WHICH IDENTITY IS CONCOMITANT WITH NEEDS OF DEPENDENT AND INTERRELATED BODIES, TO BE WITHIN ACCEPTABLE LEVELS.
	SET COMPETENCE STANDARDS	NS	RATING GIVEN BY INTERNATIONAL BODY TO EXAMINATIONS NOT TO FALL.
			REPORTED AND PROVEN INSTANCES OF MISCONDUCT OR NEGLIGENCE TO BE WITHIN TOLERABLE LIMITS.
	ENCOURAGE DISCUSSION	NS	NO. OF MEETINGS HELD ANNUALLY FOR LEARNED DISCUSSION TO BE ABOVE A CERTAIN NUMBER.
			FACILITY FOR PAPER PUBLICATION TO BE ACCEPTABLE TO MEMBERS.

TABLE II (Continued)

ENTITY	FUNCTIONS		PERFORMANCE PARAMETERS
	NAME	TYPE	
RESEARCH AND DEVELOPMENT INSTITUTIONS	UNDERTAKE RESEARCH	P	TREND IN RATIONALIZATION OF CONSTRUCTION ELEMENTS WORK PROCESSES OMC[1] TREND IN PRODUCT INNOVATION
	DISSEMINATE INFORMATION	NS	CHANGES IN NUMBER OF PROCESSED ENQUIRIES FLOW OF RESEARCH PUBLICATIONS.
	UNDERTAKE DEVELOPMENT	NS	R & D INVESTMENT AS A % OF TOTAL INVESTMENT IN INDUSTRY TO BE ABOVE A CERTAIN FIGURE.
GOVERNMENT INFLUENCE	REGULATE PERFORMANCE	P	STABILITY IN CONSTRUCTION INDUSTRY'S OWN PERFORMANCE PARAMETERS (% OF GNP AND % OF GFCF)
	PROVIDE LEGLISLATIVE FRAMEWORK	NS	ENHANCEMENT OF ENVIRONMENT AS EXPRESSED BY PUBLIC OPINION TO FOLLOW ACCEPTABLE TREND.
			DEGREE OF PUBLIC SATISFACTION WITH INDUSTRY'S PRODUCT TO BE ABOVE AN ACCEPTABLE LEVEL.
	PROVIDE FINANCIAL FRAMEWORK	NS	DEGREE TO WHICH ADEQUATE FUNDS ARE AVAILABLE TO PROCURE CF'S
FUND OF KNOWLEDGE	BE AVAILABLE	P	DEGREE OF DIFFICULTY EXPRESSED BY USERS IN ACQUIRING INFORMATION TO BE WITHIN ACCEPTABLE TOLERANCE LIMITS. (PERIODIC SURVEYS REQUIRED).
	UPDATE INFORMATION	NS	FOR LIBRARIES, CHANGES IN THE RATIO OF MAN HOURS SPENT ON UPDATING INFORMATION TO TOTAL MAN HOURS
MANUFACTURING PROCESS	PRODUCE MATERIALS	P	%INCREASE IN PRODUCTIVITY TO FOLLOW SOME ACCEPTABLE TREND.
			TIME BETWEEN PROVED INNOVATION AND ADAPTABILITY TO BE BELOW A CERTAIN LEVEL
	MARKET MATERIALS	NS	MATERIAL LEAD TIMES TO BE WITHIN TOLERABLE LIMITS.

(1) OMC denotes Organization and Management of Construction.

TABLE II (Continued)

ENTITY	FUNCTIONS		PERFORMANCE PARAMETERS
	NAME	TYPE	
ASSEMBLY PROCESS	PRODUCE CF'S	P	WORKING CAPITAL TURNOVER TO BE ABOVE A CERTAIN FIGURE. TIME, COST AND QUALITY STANDARDS TO BE MAINTAINED.
CONSTRUCTED FACILITIES (BUILDING)	PROVIDE SHELTER	P	SATISFY SPECIFIC PERFORMANCE REQUIREMENTS AS A CONSTRUCTED FACILITY REGARDING: (1) SUITABILITY TO THE SPECIFIC FUNCTION FOR WHICH COMMISSIONED (2) INSULATION (3) MAINTENANCE REQUIREMENTS (4) ACOUSTICS (5) DURABILITY (6) SPACE USAGE
	IMPROVE BUILT ENVIRONMENT	NS	LEVEL OF PUBLIC DISCONTENT TO BE WITHIN ACCEPTABLE LEVELS REGARDING: (1) ABILITY OF CF TO EXPRESS UNIQUE ETHOS OF COMMUNITIES (2) ARCHITECTURAL EXPRESSION
	OPERATE ECONOMICALLY	NS	COST IN USE TRENDS TO BE WITHIN ACCEPTABLE LEVELS
CONSTRUCTED FACILITIES CIVIL ENGINEERING	PROVIDE SUPPORT SYSTEMS	P	SATISFY SPECIFIC PERFORMANCE REQUIREMENTS AS A CONSTRUCTED FACILITY REGARDING: (1) SUITABILITY TO THE SPECIFIC FUNCTION FOR WHICH COMMISSIONED (2) DURABILITY (3) SPACE USAGE (4) MAINTENANCE REQUIREMENTS, ETC.
	OPERATE ECONOMICALLY	NS	COST IN USE TRENDS TO BE WITHIN ACCEPTABLE LIMITS
	IMPROVE BUILT ENVIRON MENT	NS	LEVEL OF PUBLIC DISCONTENT TO BE WITHIN ACCEPTABLE LEVELS REGARDING: (1) ABILITY OF CF'S TO EXPRESS UNIQUE ETHOS OF COMMUNITIES (2) ARCHITECTURAL EXPRESSION

TABLE II (Continued)

ENTITY	FUNCTIONS		PERFORMANCE PARAMETERS
	NAME	TYPE	
COMPONENTS	FACILITATE CONSTRUCTION	P	LEAD TIMES TO BE WITHIN TOLERABLE LIMITS. SATISFY SPECIFIC PERFORMANCE REQUIREMENTS.
RAW MATERIALS	FACILITATE MANUFACTURE	P	LEAD TIMES TO BE WITHIN TOLERABLE LIMITS SATISFY SPECIFIC PERFORMANCE REQUIREMENTS
ENERGY	DO WORK	P	DEGREE OF EFFICIENCY AND PRODUCTIVITY TO BE WITHIN ACCEPTABLE LEVELS

It needs to be pointed out that great care was taken to ensure that no entity's functional descriptions or performance parameters incorporated or concealed a function or performance parameter of any of the component entities. For example, the construction industry whose primary function is "provide constructed facilities" would not contain performance parameters for constructed facilities. The constructed facilities have their own specific functions to fulfil and also have assigned to them performance parameters deemed capable of indicating degree of function fulfilment.

A reading of Table II in conjunction with Figure 8 adds the dimension of purpose to the constituent entities of the morphological representation and also, of course, to the entity "construction industry".

Table III shows the international consensus opinion as to what are the resources or inputs required of and the outputs from the construction industry as a whole and of each of its constituent entities.

Footnotes are used in each table by way of explanation in situations where a direct reading of the table might lead to obscurity of meaning. For example, an Organizational Form is set up to deal with each request to the construction industry for a constructed facility or group of constructed facilities. Thus, when an Organizational Form has discharged its mandate the expertise assigned to it returns whence it came. Such interpretation of meaning is conveyed in the footnotes.

TABLE III

ENTITY	INPUTS TO	OUTPUTS
CONSTRUCTION INDUSTRY	REQUESTS FOR CF'S FACTORS OF CONSTRUCTION INFORMATION EXOGENOUS FORCES[1]	CONSTRUCTED FACILITIES REQUESTS FOR FACTORS OF CONSTRUCTION INFORMATION
MANAGERIAL PROCESS BASIC PROCESS SUPPORT PROCESS	THESE ARE GENERIC PROCESSES	
ORGANIZATIONAL FORM	INFORMATION EXPERTISE RESOURCES	INFORMATION CF REPRESENTATIONS CF REALIZATION SCHEDULES EXPERTISE [2]
PROFESSIONAL PRACTITIONER ORGANIZATIONS	COMMISSIONS INFORMATION EXPERTISE RESOURCES	EXPERTISE[3] RESOURCES INFORMATION
CONSTRUCTING ORGANIZATION	COMMISSIONS INFORMATION EXPERTISE RESOURCES	INFORMATION RESOURCES EXPERTISE[3]
EDUCATIONAL INSTITUTIONS	INFORMATION PERSONNEL FOR EDUCATING AND TRAINING EXPERTISE	INFORMATION/KNOWLEDGE EDUCATED AND TRAINED PERSONNEL EXPERTISE[4]

(1) These constitute the environmental forces resulting in forces of change being set up within the construction industry causing it to evolve. These exogenous forces do not, therefore, have a specific output.

(2) Each commission warrants a separate Organizational Form being set up to deal with it; consequently on completion of assignment the expertise returns whence it came.

(3) Expertise as an output in this context is to signify either an input to Organizational Form or as input to another entity due to people changing jobs.

(4) Expertise as an output in this context is to signify an input to another entity due to people changing jobs.

TABLE III (Continued)

ENTITY	INPUTS TO	OUTPUTS TO
PROFESSIONAL BODY INSTITUTIONS	EXPERTISE INFORMATION	AWARDS INFORMATION/PROCEEDINGS ACCREDITATIONS STANDARDS
RESEARCH AND DEVELOPMENT ORGANIZATIONS	INSTRUCTIONS/ COMMISSIONS EXPERTISE INFORMATION RESOURCES	INFORMATION/KNOWLEDGE EXPERTISE
GOVERNMENT INFLUENCE	INFORMATION EXPERTISE	INFORMATION/INSTRUCTIONS LEGISLATION FINANCE
FUND OF KNOWLEDGE	INFORMATION EXPERIENCE	INFORMATION
MANUFACTURING PROCESSES	EXPERTISE RESOURCES	COMPONENTS MATERIALS
ASSEMBLY PROCESS	COMPONENTS MATERIALS RESOURCES EXPERTISE	CONSTRUCTED FACILITIES

CHAPTER V

THE CONSTRUCTION INDUSTRY – MORPHOSTASIS AND MORPHOGENESIS

It was stated in Chapter II that the dichotomy of forces acting both on and within the construction industry results in two concomitant sequences of activities, one pertaining to the system's primary and necessary secondary functions' fulfilment, and the other concerning the system's evolution. It is the latter we are concerned with here. The construction industry as a complex, open system, mediates between the dichotomy of forces acting on and within itself. This mediating process is in itself, complex, and takes place at many levels:

- the level of the construction industry in interaction with its environment,
- the level of the construction industry's component entities, when treated as a system in their own right, in interaction with their environment,
- at successive subordinated levels.

These mediating processes at the level of our consideration are to a large extent autonomous and determinative of behaviour. They serve the following functions:

- temporarily adjusting the construction industry and its component entities to cope with external contingencies. As an illustration of this consider how the construction industry temporarily adjusted its existing construction methods and techniques in the German Democratic Republic at the end of the second world war in order to meet the unprecedented heavy demand made on it. This demand is evidenced by the form of the Reconstruction Act of 1950 and by the policies pertaining to Town Planning then in vogue,

- directing the construction industry and its component entities towards more congenial environments. Again referring to the immediate post-war German situation the strains imposed on the construction industry in endeavouring to increase production to meet the demand became excessive. The temporary adjusting of the conventional construction methods and technologies no longer proved congenial to the construction industry environment and so, as a result of the mediating processes, a programme for the industrialisation of construction activity was drawn up. [12] This served the purpose of directing the construction industry towards a more congenial environment
- permanently reorganising aspects of the construction industry to deal perhaps more effectively with the environment. In the immediate post second world war German Democratic Republic this took the form of implementing the following innovations:
  - systems designs,
  - large-scale pre-fabrication of complete standardized components in locally established component factories,
  - site assembly using the most up-to-date technologies ,
  - flow-line site production.

As a second example of the permanently reorganising aspects of the construction industry by the mediating processes consider the construction industry's response to government influence in The

(12)

"Optimum Use of Alternative Construction Technologies", Long-term Prospects and Policies in the Construction Sector, United Nations, New York, 1970, p. 86.

Netherlands in the late 1960's.[13] Here the government recognised that it could use the construction industry as a means through which to influence the national economy by guiding programmes of direct spending towards the construction industry when it warranted a boost and by consciously restricting the volume of construction output in periods of economic hyperactivity. The construction industry in order to cope with this flexibility of activity demanded of it, built up an inventory of designs and specifications for constructed facilities in the public sector that could be drawn on when employment needed a boost. The constructed facilities selected for design were taken from the normal central and local government investment programmes. They were also those constructed facilities which due to being assigned a low priority rating did not qualify for implementation during the period of their selection. There was also a continual updating of this file of proposed constructed facilities.

The theory of those mediating processes might be better understood by considering it firstly at the biological systems level and then monitoring its development for application at the adoptive systems level.

Cannon,[14] concerned about the dynamic, processual potential-mediating properties of basically unstable physiological systems, wrote:

"Our bodies are made of extraordinarily unstable material .... When we consider the extreme instability of our bodily structure, its readiness for disturbance by the slightest application of external forces and the rapid onset of its decomposition as soon as favouring circumstances are withdrawn, its persistence through many decades seems almost miraculous. The wonder increases when we realize that the system is open, engaging in free exchange with the outer world, and that the structure itself is not permanent, but is being continuously built up again by processes of repair....
The constant conditions which are maintained in the body might be termed EQUILIBRIA. That word, however, has come to have fairly exact meaning as applied to relatively simple physico-chemical states, enclosed systems, where known forces are balanced. The co-ordinated physiological processes which maintain most of the steady states in the organisms are so complex and so peculiar to living beings ... that I have suggested a special designation for these states, HOMEOSTASIS. The word does not imply something set and immobile, a stagnation. It means a condition - a condition which may vary but which is relatively constant".

(13)
"Role of the Construction Sector in Economic Policy", Long-term Prospects and Policies in the Construction Sector, United Nations, New York, 1976, p. 53.
(14)
Cannon, Walter B., "The Wisdom of the Body", (rev. ed.) Norton & Company Inc. New York, (1939) pp. 20-24 .

Mace,[15] in considering this concept of homeostasis found it needed extension and articulated his reasoning as follows:

"The first extension would cover the case in which what is maintained or restored is not so much an internal state of the organism as some relation of the organism to its environment. This would take care of the facts of adaptation and adjustment, including adjustment to the social environment ... the second extension would cover the case in which the goal, end or norm is some state or relation which has never previously been experienced. There is clearly no reason to suppose that every process of the homeostatic type consists in the maintenance or restoration of a norm. There is no reason whatever to suppose that the process always begins in a state of equilibrium which is then disturbed. Life may start in disequilibrium and in maladjustment, so that when the goal-directed process reaches its destination a state or relation is established that has never obtained before."

"There are, at any rate, many cases in which we require the concept of homeostasis to be extended so that it may apply not only to the restoration of an equilibrium but also to the discovery of new EQUILIBRIA".

Thus it becomes obvious that there are two distinct features resultant on a systems mediation between external and internal forces, in biological systems, one referring to homeostasis and the other to biological evolution. These may be retitled as:

- Structure - maintaining,
- Structure - elaborating or changing.

Buckley,[16] concerned with these concepts, in developing a modern systems approach to the sociocultural realm, wrote:

"At higher levels these mediating processes become more and more independent or autonomous, and more determinative of behaviour. They come to perform the operation of: (1) temporarily adjusting the system to external contingencies; (2) directing the system toward more congenial environments; and (3) permanently reorganizing aspects of the system itself to deal perhaps more effectively with the environment....

"It might be profitable to utilize more neutral terms for the two basic processes of interest to us here, namely, MORPHOSTASIS and MORPHOGENESIS. The former refers to those processes in complex system-environment exchanges that tend to preserve or maintain a system's given form, organization or state. Morphogenesis will refer to those processes which tend to elaborate or change a system's given form, structure or state. Homeostatic processes in organisms, and ritual in sociocultural systems are examples of 'morphostasis'; biological evolution, learning, and societal development are examples of 'morphogenesis'. "

(15)

Mace, C.A., "Homeostasis, Needs and Values", British Journal of Psychology **44**, (1953) pp. 204-205.

(16)
Buckley, Walter, "Sociology and Modern Systems Theory", Englewood Cliffs, New Jersey, Prentice-Hall (1967) pp. 58-59.

These concepts of morphostasis and morphogenesis apply directly to the construction industry, it being a sociocultural system in the sociocultural realm. Figure 5 can be modified to convey, conceptually, the concomitant sequences of activities continuously taking place in regard to the construction industry, resultant on the dichotomy of forces to which it is subjected. This development of Figure 5 is shown as Figure 9. Here it will be observed that the sequence of activities dealing with primary function and secondary functions' fulfilment is illustrated by the rather substantial rounded arrows. The sequence of activities pertaining to the system's evolution are shown as mediating process between the exogenous and endogenous forces.

It is necessary at this point to reflect on the fact that it was earlier developed in this report that there exist nexus between the various component entities in the construction industry and between the construction industry and its environment. Figures I and 6 attempted to convey this notion. It was also stated that these nexus should be comprehended as being essentially psychic communicative channels involving complex information exchange processes which was called a causal network. Within this causal network which facilitates feedback, it is only when the size of influence in one direction has an effect upon the size of influence in the other direction, and is in turn affected by it, that there is mutual causation. Now mutual causal relationships, or mutual feedbacks, can be either positive or negative. In situations where there is mutual negative feedback there is a counteracting deviation from purpose which results in the construction industry system striving to maintain or preserve its structure and form -

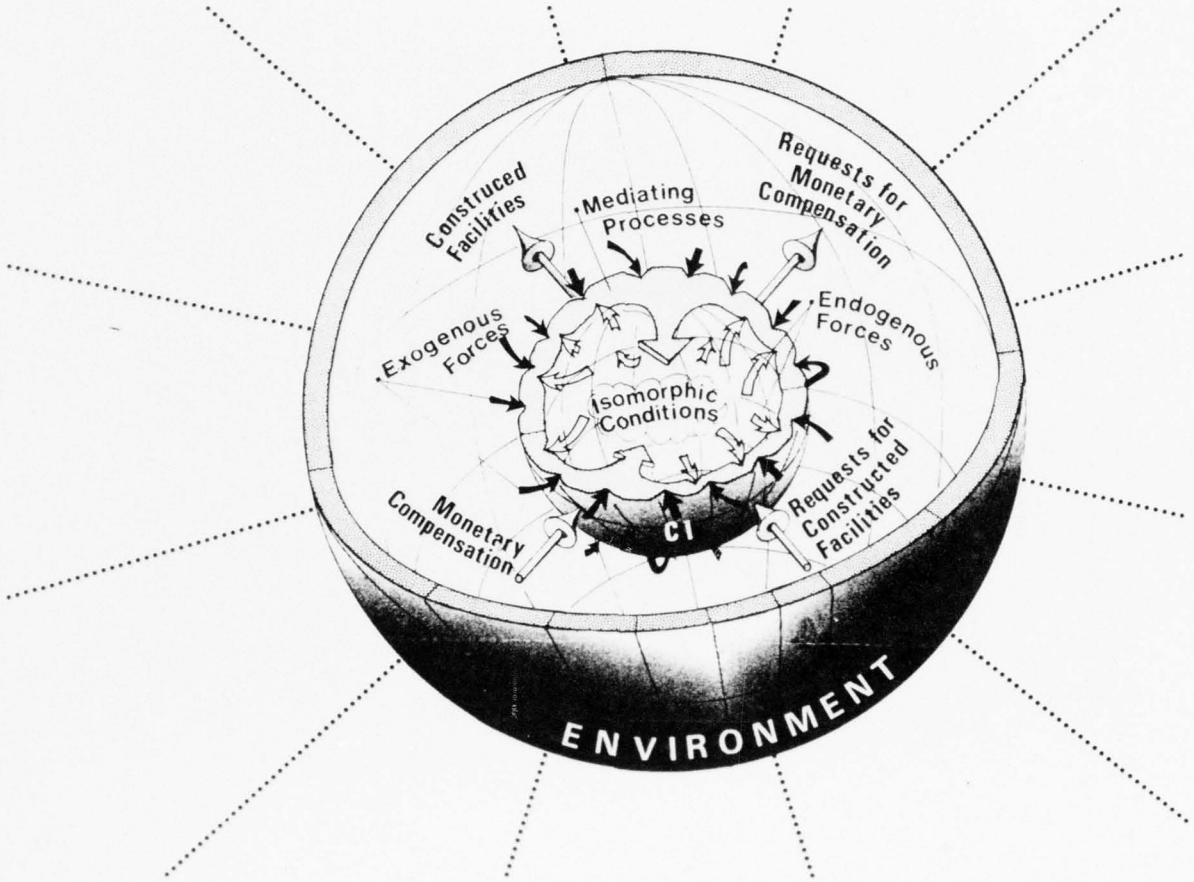
Construced Facilities
Mediating Processes
Requests for Monetary Compensation
Exogenous Forces
Endogenous Forces
Isomorphic Conditions
Monetary Compensation
CI
Requests for Constructed Facilities
ENVIRONMENT

Fig. 9.

morphostasis. Equally in situations where there is mutual positive feedback, there is a deviation from purpose that amplifies it and results in the construction industry striving to elaborate its structure and form - morphogenesis.

This dichotomy of feedback takes place concomitantly at many levels in the construction industry - the level of interaction between it and its environment, between its component entities and at successive subordinated levels. Equally, under certain conditions, deviation-amplification may become deviation counteracting and vice versa. For example, increased productivity could result, according to the nature of demand, in either an increased constructed facility population or an increased quality of product with a reduced rate of increase in the constructed facility population. If the demand let's say, is predominantly quantitative, then as productivity increased to satisfy this demand, indications are that the demographic trend would inevitably become incompatible resulting in the deviation-amplification process becoming deviation-counteracting.

At any one time in the construction industry there are many deviation-amplifying and deviation-counteracting processes taking place simultaneously. A state of inertia or a dominance of morphostatic processes is unlikely to prevail for any significant period and so we experience a construction industry that is more or less always in the process of evolution.

Causality in systems possessing morphostatic processes, is, according to Bertalanffy[17] aligned with the concept of "equifinality". This is a concept that contends that a final objective may be reached by any number of developmental routes. It must also be pointed out, of

(17)

Bertalanffy, Ludwig Von, "Problems of Life, Harper & Row, Torchbook Edition, New York, 1960 p. 142.

course, that causality in systems possessing morphogenetic processes is aligned with the concept of "multifinality". This is a concept that contends that similar initial conditions may result in dissimilar end-states. Thus the theory of causality applicable to the construction industry and its component entities as adoptive systems is a composite of equifinality and multifinality. Thus the outcome of various activities in the construction industry may not be casually dominant on or indeed relevant to the initial conditions surrounding such activities.

The morphogenic processes can be generalised to a degree by considering them in the light of the constructed facility design process. This is a situation in which the designer when presented with the client brief is unable to visualise in clear detail the end constructed facility. In point of fact, it is the deviation-amplifying processes that take place between the designer or designers and the client during the design process that generates an outcome deviant from the initial conception. At the initial commissioning of the designer the amount of information stored in his mind is much too inadequate to represent the detailed final outcome.

It is readily acceptable that it is not necessary for a designer to carry all the detailed information in his head but rather that he be possessed of the skills and rules to generate the necessary information.

This same reasoning equally applies at the level of the construction industry as a sociocultural system. There is neither enough information or decision-making ability when summed over all the construction industry's component entities to account for the complex organisation that it is. The complex organisation of the construction industry is generated by rules which are themselves generated

similarly and by the interactions among the different entities and between the construction industry and the other sociocultural systems in the sociocultural realm.

The effect of the interactions generated by the rules can be summarised as:

- limiting the scope of activity,
- providing new and revised rules,
- providing new information and understanding,
- causing change in the morphology of the construction industry and its component entities.

A diagramatic representation of the activities precipitating the occurrence of morphological change has been attempted in Figure 9 where it has also been shown that within the construction industry, positive and/or negative feedbacks are mediated by selective decisions of the different entities. In short, the mediating processes permit the construction industry to discriminate, act upon and respond to aspects of all the distinguishable entities and constraints in its environment. This process results in selective activation of the structure and form of the construction industry which becomes isomorphic in certain respects to the preceding structure and form. This ever evolving structure and form of the construction industry results in the manifestation of certain isomorphic conditions. Figure 10 identifies the various isomorphic conditions which occurred, or are likely to occur, in the evolution of the construction industry. It must be pointed out, however, that the manifestation of a technologically superior isomorphic condition does not necessarily mark the end of its predecessor; rather is it more likely that all conditions may operate simultaneously depending on the social, economic and political conditions operating at international, national or local level.

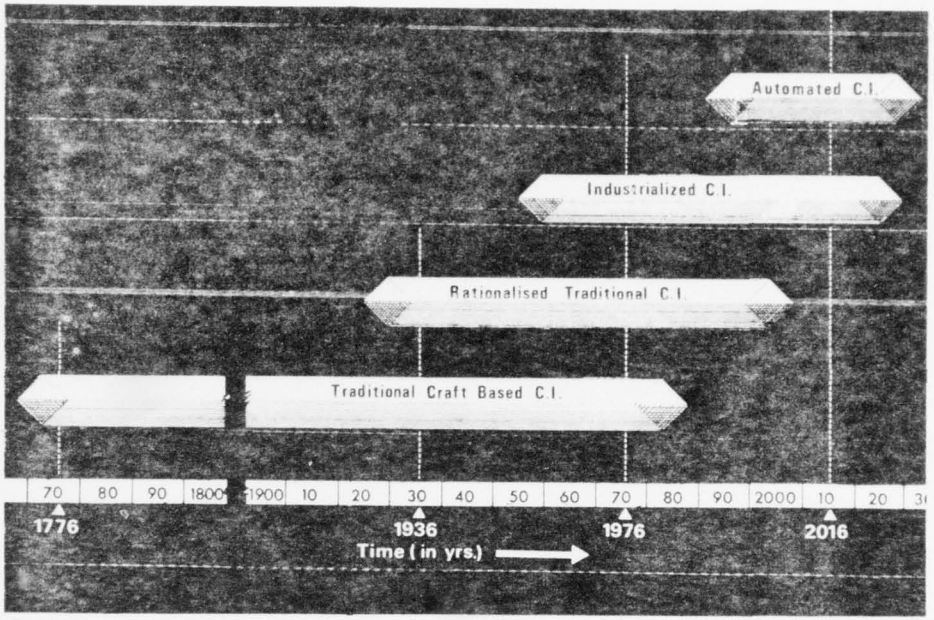
Automated C.I.
Industrialized C.I.
Rationalised Traditional C.I.
Traditional Craft Based C.I.
70
80
90
1800
1900
10
20
30
40
50
60
70
80
90
2000
10
20
1776
1936
1976
2016
Time (in yrs.)

Fig. 10.

Figure 10 also reveals that the forecasted projection for the next isomorphic condition is for a fully automated industrialised realisation process of constructed facilities' realisation. In such a condition the following would most likely be experienced:

- all work processes capable of being mechanised would be mechanised and subsequently automated,
- a full range of standardised components, mass produced using fully automated industrialised production would prevail. The dimensions of these standardised components would have been determined in accordance with a generally accepted system of dimensional coordination,
- constructed facility parts would be prefabricated using standardised components to the extent that the optimum number of parts would be used in site assembly,
- constructed facility design and the organisation and planning of its realisation would be in accordance with the most up-to-date scientific, technological and assembly techniques. The design calculations would be performed by pre-programmed computers and the constructed facility representations would be realised by numerically controlled drafting machines.

December 1978